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SERIE: PLANKTON · BIND III

NR. 1. E. STEEMANN NIELSEN: THE PRODUCTION OF PHYTOPLANKTON AT THE FAROE ISLES, ICELAND, EAST GREENLAND AND IN THE WATERS AROUND

KØBENHAVN
C. A. REITZELS FORLAG
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BY

E. STEEMANN NIELSEN

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Chapter I.

Introduction.

The production of phytoplankton at the Faroe Isles, Iceland and East Greenland is of great importance in accounting for the extensive fisheries in this region. This paper gives the results of the Danish investigations into the production of phytoplankton here during 1932—1934.

The production of phytoplankton, the chief basis of all life in the sea, is but a link in the complicated processes which lead to the production of large fish populations. The knowledge we at present possess is, however, far too slight to admit of our venturing to give a comprehensive representation of all these factors. Beyond all else, the dependence of makroplankton on phytoplankton has been very insufficiently investigated. Deficient is our knowledge of the qualitative composition of the food of the most important makroplankton organisms and practically nothing do we know regarding the quantity of the phytoplankton on which the makroplankton feed.

To begin with we must therefore investigate each single link of the chain of factors upon which the production of the fish populations are contingent. This paper is a contribution towards the solving of the problem at the beginning of the chain. The phytoplankton production will, as well as present methods permit of it being determined, be placed in relation to the physical and chemical factors.

In order to obtain a better general idea of production conditions the investigations have not been restricted to apply merely to the Faroe, Icelandic and East Greenlandic waters proper, but an attempt has also been made to deal with the whole of the northern region of the Gulfstream and the bordering colder regions. The advantages of such a modus operandi are evident.

Chapter II.

Previous investigations.

At the beginning of this century extensive investigations were instituted in regard to distribution in the aforementioned region of the larger plankton algae which are caught in silk bags.

As the most important works must be mentioned Ostenfeld 1898—1900 and 1903, and Paulsen 1904 and 1909. The setting of the problem at these researches was quite different to that dealt with here.

The methods of quantitative research of the plankton to determine the metabolism going on in the sea, taken in hand at the close of the last century by the German plankton investigator Hensen were not, in the main, followed up by the plankton investigators of other

nations. Presumably in recognition of the fact that HENSEN's methods were not possible until the systematic composition of the plankton has been discovered the research was carried on qualitatively. The influence of CLEVE's ideas — to make use of the plankton organisms as current indicators — had, without doubt, great significance as regards the methods of plankton research in those early days of hydrography.

The numerous lists of plankton in OSTENFELD's and PAULSEN's works open up, however, on account of the statements regarding the relative frequency of the various species, a possibility of occasionally using these investigations also as a supplement to a quantitative treatment of the plankton.

Quite recently HENTSCHEL (1933) undertook a quantitative investigation of the plankton in the surface waters at Iceland during a round cruise in August 1932 whereby the quantitative distribution of the plankton off the coasts of Iceland during the summer was elucidated. Also the reports by BÖHNECKE, HENTSCHEL and WATTENBERG (1930) and BÖHNECKE, FØYN and WATTENBERG (1932) regarding plankton conditions in the Denmark Strait and the Irminger Sea from materials collected on the "Meteor" expeditions in August 1929 and 1930, make an important contribution towards a comprehension of the production in this region.

At the Faroe Isles PAULSEN (1918) deals with the quantitative distribution of the plankton in May.

Chapter III.

Materials and Methods.

As already mentioned the main part of the material was collected on the cruises of the lost Danish research ship "Dana" in 1932—1934. Furthermore Magister S. LUND in June 1933 made collections on a voyage from North Iceland to North East Greenland.

In 1932 and 1934 the author took part in the "Dana" cruises, but in 1933 Dr. phil. P. JESPERSEN and Cand. mag. H. THOMSEN made the collections. All these gentlemen as well as Dr. phil. Å. V. TÅNING who as leader of the "Dana" cruises always displayed the greatest interest in the investigation of plankton and Prof. O. PAULSEN, Dr. phil., in charge of plankton department of "Kommissionen for Danmarks Fiskeri- og Havundersøgelser" are requested to accept my best thanks.

In 1932 the "Dana"s stay in the Faroe-Iceland-Greenland waters lasted from the middle of June to the beginning of August. On chart 3 pag. 16 are shown all the plankton stations. In 1933 the same waters were visited a month later, from the end of July to the end of August. On the chart 4 pag. 32 are shown the plankton stations in 1933. In 1934 the cruise took place from the end of April to the end of May. The north coast of Iceland and the waters between Iceland and Greenland were, however, not visited that year. But a trip was made out in the Norwegian Sea to the east of Iceland. The plankton stations in 1934 are shown on chart 2 pag. 10.

The plankton collections on the "Dana" cruises were made in close co-operation with the hydrographic investigations, whereby T, Cl, O_2, P_2O_5 and NO_3 were determined. On the cruise in 1934 the author also registered the degree of transparency of the water with a Pulfrich photometer. For the quantitative investigation of the plankton samples of water from depths ranging from 0, 10, 25 and 50 meters were preserved with neutral formaldehyd. At the plankton laboratory in Copenhagen the countings of the plankton were carried out with the aid of an

Utermöhls inverted microscope. In an earlier treatise (Steemann Nielsen 1933) I have demonstrated that the countings by this method, as a rule, exceed by far those obtained with the aid of Lohmann's centrifugation method, and presumably they give the actual values.

In the case of plankton species usually found in the aforementioned regions, the use of the inverted microscope is very practical. It is only when *Chaetoceros* species predominate in the plankton that the method involves the expenditure of a considerable time, for one is obliged to adopt particular measures to count the chains that are above the plane of vision. When the *Chaetoceros* chains are present in large numbers, a great many of them will easily not come within the ordinary plane of vision. The quantitative centrifugation methods described by Steemann Nielsen and v. Brand (1934) ought certainly, with the best effect, to be used for counting this kind of plankton. Yet Lohmann's centrifugation method also gives quite reliable results when a pronounced *Chaetoceros* plankton is concerned.

As preserved plankton was used for the investigation here dealt with it was, as a rule, necessary during the counting to record the small naked flagellates under one heading. This is very unfortunate as the colourless species and those with chromatophores belong, biologically, to two perfectly different groups. The number values of the flagellates have therefore been used only biologically when the main bulk consisted of easily distinguished forms like *Carteria* and *Phaeocystis*.

Chapter IV.

The general hydrographic conditions.

No complete modern work on the hydrographic conditions of the northern border regions of the Atlantic is available. While intensive hydrographic research has been carried on in most of the regions this has not been done in others. A great want will, most likely, be relieved when the material from the "Meteor" expeditions is published. The hydrography of the surface water has already been partially prepared (Böhnecke, Hentschel and Wattenberg 1930, Böhnecke 1931 and Böhnecke, Føyn and Wattenberg 1932) whereby important facts which, particularly in regard to plankton production, are of great significance, have been brought to light.

It is not possible in a work on plankton, such as this, to give a synopsis of the hydrographic literature dealing with the region, but in the various sections there will be found references to a long series of hydrographic works.

Here only quite a brief summary of the general hydrographic conditions is given. The chart 1, pag. 6 shows the general directions of the various currents in the area.

The Faroe Isles, Iceland and Greenland are situated on the submarine ridge which separates the Norwegian Sea from the Atlantic Ocean. Coincidently one here finds the boundary between the very salt Atlantic water and the less saline, cold polar and arctic waters. By arctic water is understood, according to Helland-Hansen and Nansen 1909, the water in the central part of the Norwegian Sea. It has been produced by a mingling of polar and Atlantic water. The Atlantic water has come into the Norwegian Sea through the Faroe-Shetland Channel. When the Gulf Stream coming from the south-west encounters the aforementioned submarine ridge, the main portion of the volumes of water is forced into the Norwegian Sea through the south-easternly situated Faroe-Shetland Channel. A part of the Gulf Stream is, however, forced towards the north-west and, according to Böhnecke (1931), usually reaches the Reykjanes ridge, a

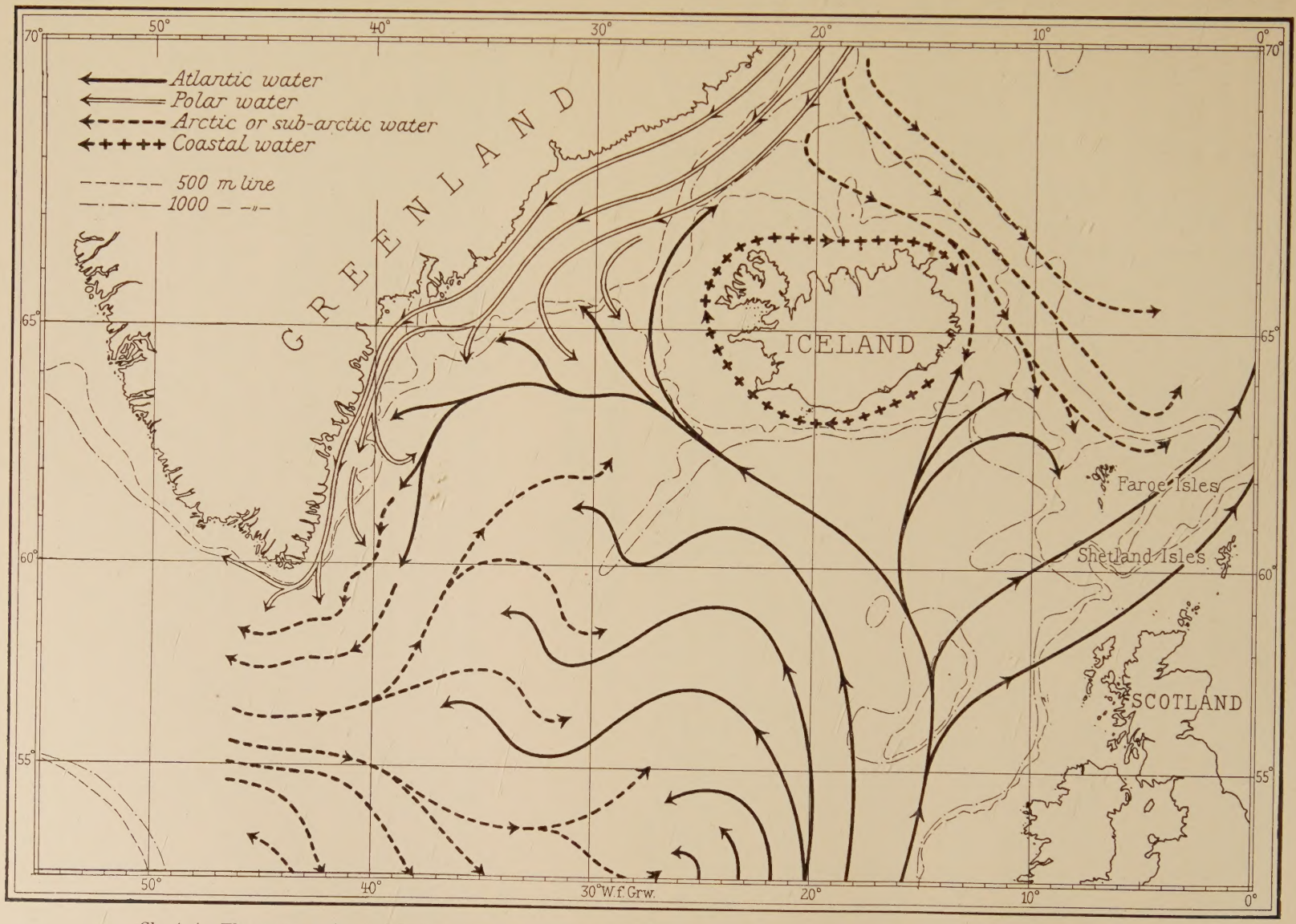

Chart 1. The currents in the northeastern part of the Atlantic and in the adjacent seas. Partly after BÖHNECKE (1931).

submarine ridge which runs out from the peninsular of Reykjanes, on Iceland, in a south-western direction. Only in the vicinity of the coast of Iceland does the water of the Gulf Stream pass over the ridge as the Irminger Stream. When this from the south side of the ridge between Iceland and Greenland has met the polar water coming from the north, it turns southwestwards and flows parallel with the coast of East Greenland and the East Greenland Current.

By mixing with water from the East Greenland Current and later on, perhaps, also with water that has its origin from the Labrador Current, a region of mixed waters is created south-east of Cape Farewell. Böhnecke (1931) describes this mixed water as sub-arctic.

A small quantity of the Gulf Stream water may sometimes, at any rate, pass over the submarine ridge between Iceland and Greenland and then, to the north of Iceland, beyond the coastal waters, it appears as an intermediate very salt layer (vide Nielsen 1905 and Helland-Hansen and Nansen 1909).

The formation of the coastal waters round the Faroe Isles and Iceland will be discussed thoroughly in chapter VII. Here we shall confine ourselves to mentioning the state of the currents off the coasts of Iceland.

The coastal waters on the south and west coasts of Iceland are formed of Gulf Stream water mixed with fresh water from the land. They move in the same direction as the hands of a clock and continue, after rounding the northwest corner of the island, along the north coast, mixed, more or less, with polar water. Off the east coast the, what is known as, the East Icelandic Current coming from the north gradually gets the complete upper hand of the warmer coastal waters originating from the Gulf Stream.

The East Icelandic Current, which conveys arctic water, when at the height of the submarine ridge between the Faroe Isles and Iceland it encounters the Gulf Stream water coming from the south, it is forced towards the east.

The East Greenland Current conveys pure polar water, which originates from the North Pole Basin. After it has come in contact with the Irminger Current over the ridge between Iceland and Greenland, the Polar Current is forced close in against the coast of Greenland and runs at a fairly rapid rate towards the south until, after reaching Cape Farewell, it is forced towards the northwest and gradually disappears. A great deal of the polar water has, however, already, while flowing along the coast of Greenland, mingled with the Gulf Stream water of the Irminger Current and thus contributes a considerable supply to the subarctic water on the south-east of Cape Farewell.

In this chapter no particulars regarding hydrographic conditions have been touched upon, nor has anything been said about the quantity of nutritive salts in the various kinds of water. This will be dealt with when discussing the basis of plankton production in the different regions.

Chapter V.

The distribution of Plankton on the various Cruises.

We shall now examine the results of the quantitative investigations from the various cruises. To obtain a correct idea of the results in the consecutive order of the seasons we must first consider the April-May cruise in 1934, then that of June-August in 1932 and lastly the July-August cruise in 1933. Later on when in a subsequent chapter the limiting factors for the plankton production are discussed, an attempt will be made to give a comprehensive idea of the annual course of production in the various sea regions.

In this chapter will be given the material on which the entire treatise rests. Therefore the reader who only wishes to learn what conclusions the author considers he can draw from the material, may skip over this chapter and begin again on page 42.

Owing to the large amount of material it was not possible to print the lists of plankton in their entirety. Though, as far as possible, all species were counted separately in all the samples, only the most important species have been given in the tables by the side of the total number of organisms of the different groups. However, as an appendix, tables have been provided showing a series of selected characteristic stations where the number of all the species are stated. Should anyone wish to study the complete lists of plankton they are available in the archive of the plankton laboratory.

April-May cruise 1934.

From the end of April to the beginning of May the "Dana" stayed at the Faroe Isles. In the coastal waters as well as in the Faroe-Shetland Channel the plankton production had not yet begun, but in the fjords it was already in progress though only in a comparatively slight degree. Diatoms, especially the Leptocylindrus species, were observed here. In table 1 will be found a summary of the distribution of the plankton at the Faroe Isles about the 1st of May. (For the Faroe-Shetland Channel vide table 2).

Table 1.

Plankton pr. 100 ccm at the Faroe Isles at the surface, April—May 1934.

	At the coast of the Faroes St. 5049 62°25′N 6°12′W $^{27}/_{4}$	Vaagfjord St. 5065 61°27′,8 N 6°45′ W $^{2}/_{5}$	Skaalefjord St. 5033 62°07′ N 6°44′ W $^{24}/_{4}$
Peridinians	..	..	420
Diatoms	..	1.130	6.180
(Leptocylindrus danicus)	..	(330)	(4.260)
(Rhizosolenia faeröense)	..	(80)	(220)
Coccolithophorides	..	..	..
Flagellates	6.400	5.200	6.000
Infusorians	60	30	40

From the Faroe Isles our course was first shaped towards the Faroebank, situated southeast of the isles. Here PAULSEN had several times in May found a vigorous production of diatoms (PAULSEN 1911 and 1918). Now, however, the production was only just beginning, but was yet considerable in proportion to the inconsiderable quantities of plankton at the stations above the deeper waters between the Faroe Isles and Iceland (vide table 2). In both places the plankton consists principally of the oceanic diatoms *Fragilaria nana* and *Nitzschia delicatissima* as well as the coccilithophoride *Pontosphaera huxleyi*.

From a hydrographic point of view both the open ocean, the Faroebank region and the coastal waters at the Faroe Isles are now characterized by an instability of the surface water. This finds an expression in an even distribution of the temperature and salinity. In the open ocean the instable conditions prevail down to a depth of about 600 m. (vide St. 5082, table 3).

Table 2.

Plankton pr. 100 ccm at the surface in the Faroe-Shetland Channel and in a section from the Faroes over the Faroebank to Iceland.

	Faroe-Shetland Channel	Between the Faroes and Faroebank	Faroebank		Between Faroebank and Iceland	
	St. 5023 61°28′ N 3°42′ W 22/4	St. 5077 61°09′ N 7°24′ W 5/5	St. 5079 60°56′ N 8°24′ W 5/5	St. 5080 61°02′ N 8°48′ W 6/5	St. 5082 61°24′ N 9°51′ W 6/5	St. 5083 62°45′ N 16°01′ W 7/5
Peridinians	..	..	50	810	90	70
Diatoms	110	810	3,500	2,930	130	190
(Nitzschia delicatissima)	(110)	(10)	(580)	(60)	(130)	(120)
(Fragilaria nana)	..	(800)	(2,400)	(2,800)	..	(70)
Coccolithophorides	..	400	5,600	2,400	400	..
(Pontosphaera huxleyi)	..	(400)	(5,600)	(2,400)	(400)	..
Flagellates	2,000	2,400	6,400	14,800	2,400	1,220
Infusorians	..	..	..	..	..	20

Table 3.

The hydrography at 3 selected stations at the Faroes, over the Faroebank and between the Faroebank and Iceland, about the 1st of May 1934.

At the coast of the Faroes St. 5049 62°25′ N 6°12′ W 27/4						Over the Faroebank St. 5080 61°02′ N 8°48′ W 6/5						Between the Faroebank and Iceland St. 5082 61°24′ N 9°51 W′ 6/5					
Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}	Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}	Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}
0	6.69	35.23	27.66	35	100	0	8.49	35.37	27.51	50	ca. 100	0	8.57	35.34	27.47	ca. 40	ca. 100
10	.69	.23	.66	35	100	10	.44	.34	.48	50	ca. 100	10	.44	.34	.49	ca. 40	ca. 100
25	.69	.23	.66	35	100	25	.41	.37	.51	50	ca. 100	25	.44	.34	.49	50	ca. 100
50	.69	.23	.66	35	100	50	.37	.37	.51	50	ca. 100	50	.44	.34	.49	50	ca. 100
80	.69	.23	.66	35	100	75	.14	.37	.51	50	ca. 100	100	.41	.32	.46	50	ca. 100
						87	.11	.34	.48	50	ca. 100	200	.40	.32	.47	50	ca. 100
												600	.33	.32	.50		
												1000	6.18	.14	.65		

The instability, a consequence of the winter convection shows itself also in the even distribution of the high phosphate and nitrate values (vide table 3).

Off the coasts of Iceland also, the waters were not yet stabilized. This was the case both as regards the water affected by the Gulf Stream on the west and south coasts and the colder arctic water on the east coast. Here also considerable quantities of nitrate and phosphate were found in all depths. Table 4 gives hydrographic data from a series of selected stations off Iceland in May 1934[1]).

[1]) Refer besides to Bulletin hydrografique where all the hydrographic data from the "Dana" cruises are published. The Bulletins for 1932 and 1933 have been issued; that for 1934 will, presumably, appear very shortly.

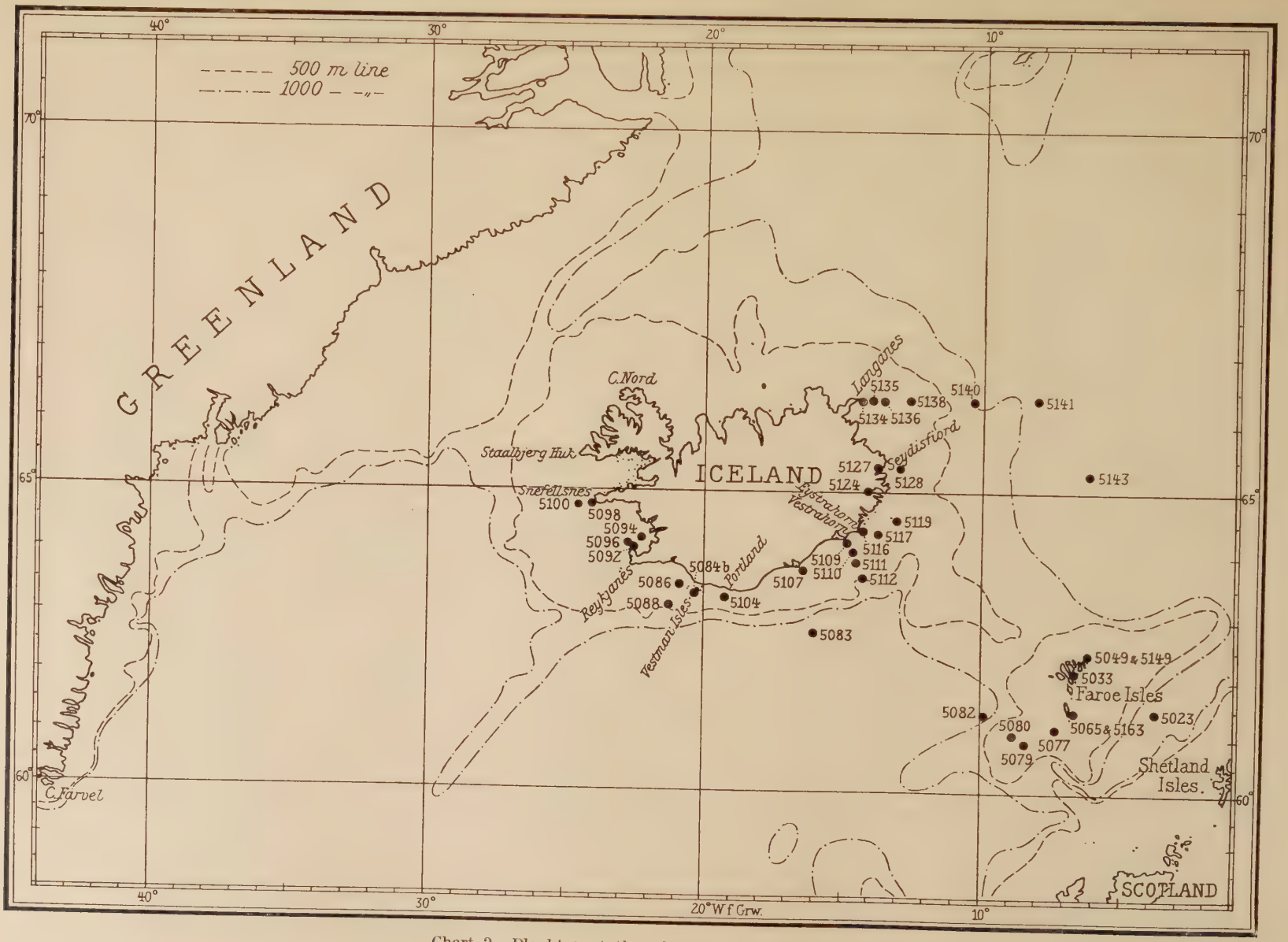

Chart 2. Plankton stations in April-May 1934.

Table 4.

The hydrography at selected stations at Iceland, May 1934.

Fakse Bay	West coast	South coast	East coast
St. 5094	St. 5098	St. 5101	St. 5135
64°14′.5 N 22°13′ W	64°47′ N 24°02 W	64°02′ N 14°41′ W	66°22′ N 14°04′ W
$^{14}/_{5}$	$^{15}/_{5}$	$^{18}/_{5}$	$^{22}/_{5}$

Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}
0	5.74	34.25	27.01	0	20
10	.58	.25	.03	ca.15	40
25	6.13	.60	.24	ca.20	80
50	6.32	.81	.39	ca.20	80

Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}
0	5.55	34.58	27.29	ca.20	60
10	.58	.58	.29	ca.20	60
25	.60	.60	.30	ca.20	60
50	.77	.76	.41	ca.35	80
70	.80	35.01	.61	ca.30	80

Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}
0	7.08	35.19	27.79	45	..
10	.18	.19	.77	45	..
25	.17	.19	.77	45	..
50	.18	.19	.77	45	..
75	.10	.19	.78	45	..
100	.10	.19	.78	40	..
120	.10	.19	.78	40	..

Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}
0	2.92	34.67	27.65	35	100
..	..	..	..	..	..
25	.68	.67	.66	25	125
50	.49	.67	.67	35	125
75	.32	.67	.69	30	125
100	.19	.67	.70	25	125
120	.16	.72	.75	35	125

Table 5.

Plankton pr. 100 ccm at the westcoast of Iceland, May 1934.

	Fakse Bay									Off Snefellsnes					
	St. 5092 64°03′ N 22°33′ W $^{12}/_{5}$		St. 5094 64°14′.5 N 22°13′ W $^{14}/_{5}$				St. 5096 64°08′ N 22°46′ W $^{15}/_{5}$			St. 5098 64°47′ N 24°02′W $^{15}/_{5}$			St. 5100 64°47′ N 24°31′W $^{15}/_{5}$		
Depth in m	0	25	0	10	25	50	0	25	50	0	25	50	0	25	50
Temperature in C	6.16	5.56	5.74	5.58	6.13	6.32	6.43	6.43	6.18	5.55	5.60	5.77	6.18	6.06	6.06
Peridinians	50	60	60	50	..	..	1,600	430	40	10	60	60	260	180	230
Diatoms	..	80	90	120	3,230	620	90	90	20	30	60	130	..	20	..
(Sceletonema costatum)	..	(30)	..	..	(2,800)	(470)	(80)	(30)	(20)	..	..	..	..	..	..
(Thalassiosira species)	..	(30)	(30)	(60)	(400)	(20)	(10)	(20)	..	(10)	(30)	(30)	..	..	..
Coccolithophorides	..	..	..	..	..	..	..	..	..	..	..	..	60	70	40
Flagellates	9,200	12,000	10,400	19,200	12,800	3,200	21,600	10,400	2,000	3,600	8,400	2,000	9,200	8,400	10,400
Infusorians	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Off the west coast of Iceland between Snefellsnes and Reykjanes the plankton production had not yet begun in the first half of May. Only flagellates, small doubtless heterotrophic species, were found in considerable numbers. The heterotrophic flagellates are, however, of but slight interest when discussing the question of production as, without doubt, they are remnants of the previous year's production. They consume the organic matter produced during the previous year.

Only at St. 5094 in the inner shallow part of the Faksebay, at depths of 25 and 50 m. were lesser plankton populations found consisting for the most part of the diatom *Sceletonema costatum*. As, at the same time, the nutritive salts were found only in minimal quantities at the surface (P_2O_5 0 mg/m², N_{NO_3} 20 mg/m³) at this station, there must recently have been plankton production here.

Table 6.

Plankton pr. 100 ccm on the south coast of Iceland, May 1934.

	St. 5086 63°31′ N 20°52′ W 9/5			St. 5088 63°11′ N 21°16′ W 9/5			Anchorage Vestmannaeya 8/5	St. 5104 63°20′.5 N 19°12′ W 16/5			St. 5107 63°46′ N 16°25′ W 17/5		
Depth in m	0	25	50	0	25	50	0	0	25	50	0	25	50
Temperature in ° C	7,23	7,23	7,23	8,03	8.01	8.01		7.23	7.33	7.37	7.40	7.41	7.40
Peridinians	20	50	30	250	90	210	50	90	50	30	..	40	80
Diatoms	840	150	110	130	30	20	20	150	60	580	1,370	810	..
(Sceletonema costatum)	(660)	(20)	(110)	..	..	..	..	(110)	(30)	(540)	(70)	..	..
(Fragilaria nana)	..	..	..	(20)	..	..	..	..	(30)	..	(1,200)	..	..
Coccolithophorides	..	..	..	..	..	..	..	..	..	20	..	..	..
Flagellates	6,000	4,000	2,800	1,600	400	800	2,400	5,200	3,200	2,400	2,000	2,000	800
Infusorians	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 7.

Plankton pr. 100 ccm in a section off Vestrahorn.

	St. 5109 64°12′ N 14°52′ W 18/5			St. 5110 64°02′ N 14°41′ W 18/5			St. 5111 63°52′ N 14°30′ W 18/5			St. 5112 63°42′ N 14°19 W′ 18/5		
Depth in m	0	25	50	0	25	50	0	25	50	0	25	50
Temperature in ° C	6.43	6.48	6.48	7.08	7.17	7.18	7.18	7.16	7.15	8.41	8.31	8.19
Peridinians	30	20	..	70	60	20	170	30	20	160	100	30
Diatoms	1,670	740	70	250	10	..	400	10	..	20	200	30
(Sceletonema costatum)	(180)	(30)	..	(220)	..	..	(200)	..	..	..	(60)	..
(Thalassiosira nordenskjöldii)	(1,030)	(550)	(40)	..	..	..	..	..	..	..	..	..
Coccolithophorides	..	..	..	80	50	..	70	90	..	40	70	30
Flagellates	800	400	800	7,200	3,200	800	1,600	800	800	3,600	2,000	2,400
Infusorians	..	..	..	..	..	..	..	..	..	..	..	..

The production in the inner parts of the shallow bays may, at any rate occasionally, begin considerably earlier than at the deeper, more exposed parts of the coastal region. Table 5 gives a synopsis of the plankton distribution in May off the west coast of Iceland and table 6 and 7 a similar one for the south coast.

The production conditions here correspond, at this time, exactly to those on the west coast. The first trace of a beginning production was found at the innermost shallow stations in the two sections Selvogsbanke-section and Vestrahorn-section, where the abundance of plankton in proportion to its paucity at the stations situated further out, was considerable. It was particularly the diatoms *Sceletonema costatum*, *Thalassiosira gravida* and *Thalassiosira nordenskjöldii* that were found.

Between Vestrahorn and Eystrahorn was found the boundary between the warm water from the Atlantic and the colder arctic water. In table 8 there is a synopsis of the distribution

Table 8.

Plankton pr. 100 ccm at East Iceland, May 1934.

	Off Eystrahorn					Off Hvalsbakur	Reydafjord		Off Seydisfjord					
	St. 5116 64°25′ N 14°18′ W 19/5			St. 5117 64°21′ N 13°46′ W 19/5		St. 5119 64°33′ N 13°03′ W 19/5	St. 5124 65°01′ N 14°07′ W 20/5		St. 5127 65°19′.5 N 13°34′ W 21/5			St. 5128 65°20′ N 12°57′ W 21/5		
Depth in m	0	25	50	0	25	0	0	25	0	25	50	0	25	50
Temperature in °C	3.27	3.28	3.26	3.23	3.18	3.08	3.10	3.14	2.81	2.80	2.83	2.86	2.86	2.85
Peridinians	240	100	40	180	130	160	280	980	1,770	2,200	860	200	880	1,600
Diatoms	17,740	14,540	11,520	1,310	920	740	31,980	12,160	770	1,530	450	180	400	430
(Thalassiosira nordenskjöldii)	(9,000)	(10,700)	(7,500)	(190)	(200)	(80)	(28,300)	(9,000)	(270)	(290)	(70)	(20)	..	(40)
(Thalassiosira gravida)	(1,980)	(880)	(1,020)	(260)	(170)	(10)	(1,100)	(680)	(120)	(80)	..	..	..	(60)
(Chaetoceros debilis)	(500)	(200)	(600)	(350)	(120)	..	(1,020)	(1,300)	..	(120)	..	..	..	..
Coccolithophorides	..	..	..	10	..	..	..	..	..	30	..	..	..	..
Flagellates	6,420	4,440	2,440	7,200	5,200	8,000	17,260	18,400	10,800	12,000	6,400	8,810	12,420	11,240
Infusorians	40	..	..	..	..	80	100	20	280	110	90	20	20	40

Table 9.

Plankton pr. 100 ccm in a section from Langanes out in the Norwegian Sea, May 1934.

	St. 5134 66°22′ N 14°27′ W 22/5			St. 5135 66°22′ N 14°04′ W 22/5			St. 5136 66°23′ N 13°35′ W 22/5			St. 5138 66°23′.5 N 12°33′ W 22/5		St. 5140 66°25′.5 N 10°17′ W 23/5		St. 5141 66°23′.5 N 8°01′ W 23/5		St. 5143 65°13′ N 6°04′ W 24/5	
Depth in m	0	25	50	0	25	50	0	25	50	0	25	0	25	0	25	0	25
Temperature in °C	2.87	2.69	2.62	2.92	2.68	2.49	3.43	2.63	2.44	2.38	1.91	1.87	1.66	2.10	1.62	3.61	3.24
Peridinians	330	370	210	40	240	..	400	1,200	400	810	3,600	800	1,260	2,800	2,810	1,610	2,020
Diatoms	670	840	110	940	740	310	760	910	330	2,680	1,980	520	440	1,390	400	630	480
(Thalassiosira species)	(90)	(90)	(70)	(190)	(160)	(110)	(260)	(240)	(200)	(90)	(150)	..	..	(40)	(90)	(120)	..
(Fragilaria nana)	(420)	(380)	..	(30)	(200)	..	(120)	(230)	..	(2,400)	(1,600)	(260)	(280)	(130)	(200)	(20)	(110)
(Nitzschia delicatissima)	(20)	(60)	..	(200)	(200)	(50)	(110)	(60)	..	(100)	(80)	(250)	(90)	(1,200)	(110)	..	(30)
Coccolithophorides	..	10	..	20	40	40	..	..	..	30	..	120	200	300	290	3,600	2,800
(Coccolithophora pelagica)	..	..	..	(10)	(10)	..	..	..	..	..	..	(60)	(120)	(230)	(190)	(1,200)	(1,200)
Flagellates	14,000	7,200	5,600	12,800	13,600	4,400	16,000	10,090	3,600	14,000	10,800	24,000	22,000	22,450	22,450	12,000	15,000
Infusorians	50	70	50	50	160	..	..	40	..	..	90	10	10	40	80	630	50

Table 10.

Plankton pr. 100 ccm at the surface at the Faroes at the end of May 1934.

	At the coast of the Faroes St. 5149 62°25′ N 6°12′ W $^{25}/_{5}$	Vaagfjord St. 5163 61°27′.8 N 6°45′ W $^{28}/_{5}$
Peridinians	80	30
Diatoms	17,270	7,050
(Sceletonema costatum)	(10,400)	(4,000)
(Thalassiosira nordenskjöldii)	(1,540)	(30)
(Chaetoceros furcellatus)	(1,420)	(150)
(Nitzschia seriata	(800)	(1,200)
Coccolithophorides (Pontosphaera)	400	400
Flagellates	4,400	5,200
Infusorians	20	..

of plankton at this time on the east coast of Iceland. The production conditions seem to correspond to the conditions prevailing in the Atlantic coastal waters.

At the inner station of the Eystrahorn section a fairly vigorous plankton production was found and also beyond this at stations situated closest to the land. The beginning of the spring maximum was distinctly to be observed. In the sheltered Reydafjord (St. 5124) a considerable quantity of plankton was found. The species found at this time on the east coast are partly the same as those in the warmer coastal water of the Atlantic. *Sceletonema costatum* was the only one missing, but several *Chaetoceros* species were found instead. The stations 5140—5143 form a natural continuation of the Langanes section out in the Norwegian Sea. The surface water is beginning to be stabilized (vide St. 5143 table 76, appendix) and the spring maximum is just beginning (vide table 9).

For the sake of comparison, it must not be forgotten that the season during the cruise has steadily advanced; more than a fortnight has passed since the "Dana" crossed the Atlantic between the Faroe Isles and Iceland. In the Norwegian Sea, besides various coccolithorides (particularly *Coccolithophora pelagica*) both a quantity of diatoms and peridinians were now found. Particularly St. 5143 is interesting with regard to the composition of the plankton (vide table 76, appendix). It is distinctly to be seen that the arctic water in the central part of the Norwegian Sea is formed by a blending of Gulf Stream water and cold neritic water from the East Greenland Current or East Iceland. Diatoms, such as *Corethron criophilum* and *Thalassiothrix longissimum* along with the coccolithophorides *Pontosphaera huxleyi* and *Michaelsarsia* spec. are typical Gulf Stream species while the diatom *Chaetoceros debilis* is neritic.

Finally St. 5149 and St. 5163 lie in the coastal region at the Faroe Isles. While in the beginning of the month plankton production had only started in the fjords it was now in progress everywhere (table 10). The plankton consists almost exclusively of diatoms. *Sceletonema costatum* is the most frequent species (up to 10,400/100 ccm.). In addition must be mentioned the *Thalassiosira* species and *Nitzschia seriata*. The surface water is not stabilized. Nutritive salts are present in fairly large quantities (table 11).

Table 11.

The hydrography at the coast of the Faroes at the end of May 1934 (St. 5149).

(62°25′ N 6°12′ W $^{25}/_{5}$)

Depth in m	t	S ‰	σ_t	P_2O_5	N_{NO_3}
0	7.61	35.25	27.54	25	ca. 90
10	.56	.25	.54	35	ca. 100
25	.56	.23	.53	30	ca. 100
50	.56	.23	.53	30	ca. 100
75	.56	.26	.56	30	ca. 100

June to August cruise 1932.

In the middle of June the "Dana" stayed at the Faroe Isles. While in the Faroe-Shetland Channel there is at this time to be seen a typical oceanic plankton (vide table 12) which corresponds fairly well both quantitatively and qualitatively to the plankton now to be found out in the open ocean, there is, on the contrary, in the coastal waters at the Faroe Isles a plankton consisting principally of neritic diatoms (table 64, appendix). *Nitzschia delicatissima* is the most numerous species, but as regards production, *Rhizosolenia færöense* with its — in proportion to *Nitzschia delicatissima* — gigantic cells, plays a very important part. The even vertical distribution of temperature, salinity, plankton and nutritive salts points to vigorous vertical mixing (table 64, appendix).

Table 12.

Plankton pr. 100 ccm at the surface in the northerly Atlantic and Faroe—Shetland Channel in June 1932 (Vide besides table 56, appendix).

	Faroe-Shetland Channel	Northerly Atlantic	
	St. 4373 60°15′ N 6°43′ W 12/6	St. 4400 62°21′ N 11°00′ W 24/6	St. 4402 62°23′ N 16°05′ W 25/6
Peridinians	2,500	8,640	5,340
Diatoms	1,630	6,450	4,220
(Thalassiosira sp.)	(1,200)	(2,000)	(200)
(Nitzschia delicatissima)	(60)	(4,000)	(3,600)
Coccolithophorides	22,000	95,620	86,200
(Pontosphaera huxleyi)	(21,600)	(90,400)	(76,000)
Flagellates	22,800	22,000	5,200
Infusorians	150	240	750

While the plankton in the open Vaagfjord corresponded to a certain degree to the plankton outside (*Rhizosolenia faeröense* was, however, not found) that in the tresholdfjord Skaalefjord was very poor (vide table 13).

From the Faroe Isles the course was laid towards the south coast of Iceland. Sts. 4400 and 4402 lie on the open ocean, south of the ridge between Iceland and the Faroe Isles. The plankton is typical of the whole of the northern Gulf Stream area (table 12 and table 56, appendix). At this time it is quantitatively very rich. The little cocolithophorid *Pontosphaera huxleyi* was found numerically in excess of 100,000/100 ccm. In contrast to the May cruise the surface water is, on account of the summer warming, stabilized (vide table 56, appendix).

Table 13.

Plankton pr. 100 ccm at the surface at the Faroes in the middle of June 1932 (Vide besides table 64, appendix).

	Vaagfjord St. 4382 15/6	Skaalefjord St. 4392 62°07′ N 6°44′ W 22/6	Coast of Faroe Isl. St. 4399 62°21′ N 7°16′ W 23/6
Peridinians	2,400	450	420
Diatoms	23,850	850	12,360
(Thalassiosira species)	(9,600)	..	(60)
(Chaetoceras species)	(13,200)	..	(1,560)
(Rhizosolenia faeröense)	..	..	(2,200)
(Nitszachia delicatissima)	(250)	(150)	(5,100)
Coccolithophorides (Pontosphaera)	..	..	800
Flagellates	10,800	6,000	9,600
Infusorians	50	1,600	80

Chart 3. Plankton stations in June-August 1932.

During the production the main portion of the nutritive salts are consumed at the surface. Presumably the last remnants will also soon have disappeared and a summer minimum for the plankton, typical of the North Atlantic Ocean, will occur.

Sts. 4403—4413 lie off the south coast of Iceland between Portland and Reykjanes. As far as the plankton is concerned there is, however, a difference between the stations lying to the east 4403 and 4407 off the Vestman Islands (table 14) and those to the west 4410—4413 (table 15). This will be more clearly explained in chapter VII; here it is merely to be remarked that in the close vicinity of the Vestman Islands there is a constant supply of nutritive deepwater to the surface layers, throughout the summer. This is evident from the high values of the nutritive salts in the surface water at St. 4003 in connection with the even, vertical distribution of temperature and salinity.

The extraordinarily high values for the diatoms at St. 4003 and St. 4007 (vide table 14) are a sign of a very large production. The plankton is typically neritic corresponding to the Asterionella-plankton of Ostenfeld (1898—1900). Quantitatively prominent are especially the diatoms *Leptocylindrus minimus*, *Chaetoceros cinctus*, *Asterionella japonica* and *Nitzschia delicatissima*, but also a long range of other diatoms as well as peridinians and coccolithophorides in no inconsiderable numbers (vide table 00, appendix).

The westerly stations 4410—4413 are noticeable, hydrographically, for stabilized surface water where the nutritive salts have now been used up. Only at the ultimate station in the Reykjanes section (St. 4413) were phosphate and nitrate found at the surface. However, that until recently there must have been nutritive salts in the surface water everywhere is evident from the high numbers of plankton (table 15).

The plankton consists for the greater part of diatoms and coccolithophorides. The species are, to some extent, the same as those found around the Vestman Islands.

Table 14.

Plankton pr. 100 ccm at the south coast of Iceland near the Vestman Island, June 1932.

	St. 4403 63°24′.5 N 20°18′ W $^{26}/_{6}$			St. 4407 63°30′.5 N 20°04′.5 W $^{27}/_{6}$		
Depth in m.	0	10	25	0	10	25
Temperature in ° C.	9.40	9.34	9.30	..	..	..
Salinity, ‰	35.16	35.16	35.16	..	..	..
σ_t	27.20	27.21	27.21	..	..	..
P_2O_5, mg/m³	25	25	20	..	..	..
N_{NO_3}, mg/m³	55	55	65	..	..	..
Peridinians	1,580	1,220	2,120	1,600	3,500	1,650
Diatoms	79,780	72,100	89,720	212,200	524,600	78,300
(Leptocylindrus minima)	(8,800)	(5,200)	(6,200)	(140,000)	(436,000)	(39,000)
(Chaetoceros cinctus)	(38,040)	(35,380)	(42,160)	(44,500)	(37,750)	(17,400)
(Asterionella japonica)	(22,000)	(17,800)	(21,900)	(6,500)	(14,700)	(8,250)
(Nitzschia delicatissima)	(9,200)	(10,400)	(13,600)	(9,600)	(24,000)	(4,000)
Coccolithophorides	7,200	6,800	8,400	10,000	6,400	6,400
(Pontosphaera huxleyi)	(6,800)	(6,400)	(7,200)	(9,200)	(6,000)	(5,600)
Flagellates	4,000	4,800	8,440	3,800	10,000	6,050
Infusorians	240	240	260	900	400	250

Table 15.

Plankton per 100 ccm at the south coast of Iceland west of the Vestman Islands, June 1932.

	St. 4410 63°52′.5 N 21°22′ W 28/6		St. 4411 63°49′ N 22°11′ W 28/6			St. 4412 63°42′ N 22°17′ W 28/6			St. 4413 63°34′ N 22°25′ W 28/6			
Depth in m	0	10	0	10	25	0	10	25	0	10	25	50
Temperature in ° C	10.24	10.00	10.58	10.56	9.91	10.61	10.44	9.97	10.14	10.17	10.20	8.41
Salinity, ‰	29.38	35.02	33.61	34.67	34.88	34.83	34.83	35.03	35.17	35.17	35.16	35.23
P_2O_5, mg/m³	10	10	5	0	0	0	5	5	10	10	15	40
N_{NO_3}, mg/m³	0	15	0	0	15	0	0	0	40	45	40	125
Peridinians	2,360	1,820	2,620	6,550	680	1,440	2,760	2,160	5,160	2,360	3,640	470
Diatoms	95,950	4,990	130,800	243,380	39,280	70,780	55,260	21,340	21,320	30,580	53,420	4,200
(Leptocylindrus minima)	(71,600)	(2,200)	(61,000)	(192,000)	(2,800)	(39,200)	(28,000)	(1,600)	(11,200)	(19,200)	(42,800)	(2,200)
(Chaetoceros cinctus)	(120)	(190)	..	(1,000)	(560)	(220)	..	..	..	..	..	..
(Asterionella japonica)	(20)	(190)	(100)	..	(100)	(200)	..	(40)	..	..	..	..
(Nitzschia delicatissima)	(22,000)	(1,800)	(65,000)	(47,200)	(36,800)	(26,800)	(22,400)	(17,600)	(2,800)	(4,800)	(2,800)	(1,800)
Coccolithophorides	9,600	31,200	41,200	28,400	42,400	64,400	88,800	88,400	93,200	98,800	82,400	10,000
(Pontosphaera huxleyi)	(9,600)	(30,400)	(39,600)	(27,200)	(42,400)	(64,000)	(88,400)	(87,600)	(92,800)	(98,800)	(82,000)	(10,000)
Flagellates	24,400	15,600	24,620	10,800	11,600	8,000	7,200	10,400	16,800	31,200	22,000	1,900
Infusorians	550	220	520	980	330	580	520	440	3,420	2,420	2,980	320

Table 16.

Plankton per 100 ccm in the Fakse Bay about the 1st of July 1932.

	St. 4414 off Skagi 64°08′ N 22°46′ W 29/6			St. 4415 off Akranes 64°14′.5 N 22°13′ W 29/6			St. 4421a 64°00′ N 22°32′ W 1/7	St. 4421b 64°00′ N 22°32′ W 3/7		
Depth in m	0	10	25	0	10	25	0	0	10	25
Temperature in ° C	9.57	9.57	8.84	9.38	9.90	9.18	..	10.53	9.96	8.87
Salinity, ‰	34.59	34.61	34.92	34.56	34.54	34.74	..	34.39	34.57	34.92
P_2O_5, mg/m³	5	5	30	5	5	10	..	20	15	50
N_{NO_3}, mg/m³	5	5	90	5	10	25	..	0	10	100
Peridinians	5,300	5,000	1,000	2,640	6,710	5,490	1,660	1,090	1,540	300
Diatoms	239,400	236,500	7,000	46,820	72,260	117,580	88,100	9,460	25,760	55,400
(Leptocylindrus minima)	(94,000)	(72,400)	(350)	(22,000)	(26,000)	(13,400)	(42,400)	(440)	(12,000)	(32,400)
(Chaetoceros cinctus)	(33,000)	(49,000)	(500)	(2,700)	(5,220)	(13,880)	(16,600)	(4,840)	(5,040)	(2,000)
(Asterionella japonica)	(49,700)	(46,800)	(4,250)	(2,400)	(3,320)	(24,700)	(700)	(220)	(180)	(4,600)
(Nitzschia delicatissima)	(45,200)	(56,000)	(1,400)	(16,400)	(32,000)	(48,000)	(13,200)	(1,120)	(3,600)	(9,200)
Coccolithophorides	4,800	9,300	20,000	1,200	5,600	8,800	4,400	..	1,600	4,000
(Pontosphaera huxleyi)	(4,800)	(9,200)	(20,000)	(1,200)	(5,600)	(8,800)	(4,400)	..	(1,600)	(4,000)
Flagellates	18,800	23,700	10,000	452,040	168,100	95,040	19,100	15,200	21,000	8,200
Infusorians	1,900	900	400	540	930	580	480	500	340	360

The predominating species here, *Chaetoceros cinctus* and *Asterionella japonica*, are, however, almost entirely lacking. On the other hand the coccolithophorid Pontosphaera huxleyi generally play a great part. This species is particularly, though not exclusively, an oceanic one.

The maximum at the most extreme station 4013 in the Reykjanes section is therefore to be understood and likewise the vertical main distribution at St. 4410 in the deeply lying more salty water.

Sts. 4414—4421 were taken from the 29th June to 3rd July in the Fakse Bay. The hydrographic conditions are similar to those at the westerly stations on the south coast. The nutritive salts are present in but inconsiderable quantities at the surface (table 16); while the plankton at some stations still appeared in large quantities at the surface, a distinct sinking of the plankton was ascertained at some others viz. St. 4415 and St. 4421 b, where at the same time a fairly large quantity of resting spores of *Chaetoceros cinctus* was observed. Two days before St. 4421 b was taken, a rich plankton was found in the surface water on the same spot, St. 4421 a.

The dominating species of the plankton are the same as on the south coast: *Leptocylindrus minima*, *Chaetoceros cinctus*, *Asterionella japonica* and *Nitzschia delicatissima* and besides the composition of the plankton is also the same as at that place.

The inner station at Snefellsnes, St. 4425 and the two at Staalbjerghuk, Sts. 4427 and 4428 are, as far as the plankton is concerned, in the same category as the stations in the Fakse Bay (table 17). The spring maximum here is also about to disappear. At the outer station at Snefellsnes, St. 4426, on the contrary, quite another plankton was found (table 18).

We have here reached out into the Irminger Stream which now is characterized by high values of nutritive salts in the surface layers. The plankton is purely oceanic and will be dis-

Table 17.

Plankton per 100 ccm at the west coast of Iceland in the beginning July 1932.

	Off Snefellsnes	Off Staalbjerghuk					
	St. 4425 64°47′ N 24°13′ W $^{8}/_{7}$	St. 4427 65°26′ N 24°31′ W $^{8}/_{7}$		St. 4428 65°42′ N 25°32′ W $^{8}/_{7}$			
Depth in m	0	0	25	0	10	25	50
Temperature in ° C	10.37	8.78	8.70	8.11	8.04	7.94	7.08
Salinity, ‰	34.98	34.81	34.81	34.97	34.96	34.96	34.96
σ_t	26.89	27.02	27.04	27.26	27.26	27.28	27.40
P_2O_5, mg/m³	0	20	20	20	20	20	40
N_{NO_3}, mg/m³	0	50	40	—	—	—	—
O_2, perc. of sat.	105.6	93.8	93.8	96.7	97.3	96.2	94.3
Peridinians	1,090	1,160	1,060	2,560	700	1,140	140
Diatoms	10,500	1,090	1,480	13,740	9,740	6,880	13,220
(Leptocylindrus minima)	(500)	(210)	(150)	(300)	(80)	(250)	1,860)
(Chaetoceros cinctus)	(4,000)	..	..	..	..	..	..
(Chaetoceros laciniosus)	..	..	(20)	(460)	(1,250)	(500)	(620)
(Asterionella japonica)	(1,660)	..	..	..	..	(170)	(300)
(Nitzschia delicatissima)	(3,400)	(250)	(870)	(10,700)	(6,060)	(4,360)	(8,500)
Coccolithophorides	400	2,500	1,200	..	..	..	1,640
(Pontosphaera huxleyi)	(399)	(2,400)	(1,200)	..	..	..	(1,600)
Flagellates	1,600	4,400	3,220	20,000	4,000	4,050	12,820
Infusorians	160	160	130	180	140	80	80

Table 18.

Plankton per 100 ccm in the oceanic water off Snefellsnes, July 1932.

	St. 4426 64°47′ N 24°31′W $^{8}/_{7}$
Depth in m	0
Temperature in ° C	9.43
Salinity, ‰	35.18
P_2O_5, mg/m³	20
N_{NO_3}, mg/m³	80
Peridinians	1,200
Diatoms	90,620
(Chaetoceros cinctus)	(1,200)
(Nitzschia delicatissima)	(6,800)
(Fragilaria nana)	(78,400)
Coccolithophorides (Pontosphaera huxleyi)	9,600
Flagellates	68,000
Infusorians	160

cussed more fully later on. At St. 4427 at Staalbjerghuk is to be noticed the powerful tide race, which, according to "Den Islandske Lods" 1911, is always found here. By this means then, have nitrate and phosphates come up to the surface layers. This, however, has not proved to be of any benefit for the development of plankton production (vide further page 49).

From the 8th to the 16th July the "Dana" cruised in the Danmark Strait and Irminger Sea. This will be discussed at the end of this section. We shall in the meantime deal with the subsequent part of the cruise from Reykjavik, round the north of Iceland to the east coast and down to the Faroe Isles.

St. 4451 and St. 4452 are situated in the Fakse Bay, St. 4451 at Akranes where a fortnight earlier St. 4415 was worked, and St. 4452 at Skagi, corresponding to St. 4414. Here are now found only insignificant remnants of the diatom plankton which already a fortnight previously, was beginning to disappear. Nutritive salts have disappeared entirely from the surface layers (table 19).

We now find the summer peridinian plankton described by Paulsen (1904 and 1910). The cocolithophorid *Pontosphaera huxleyi*, however, plays the principal part among the producers (up to 37,000/100 ccm.). The very large quantity of naked flagellates are, without doubt, mostly heterotrophic species[1]).

Table 19.

Plankton per 100 ccm at the west coast of Iceland in the middle of July 1932.

	St. 4451 off Akranes 64°14′.5 N 22°13′ $^{18}/_{7}$			St. 4452 off Skagi 64°08′ N 22°46′W $^{18}/_{7}$			St. 4453 off Snefellsnes 64°47′ N 24°02′W $^{18}/_{7}$	St. 4454 off Staalbjerghuk 65°26′ N 24°31′W $^{19}/_{7}$
Depth in m	0	10	25	0	10	25	0	0
Temperature in ° C	11.42	11.04	8.90	11.24	11.24	9.67	11.53	9.38
Salinity, ‰	34.60	34.63	34.91	34.52	34.52	34.76	34.58	34.87
P_2O_5, mg/m³	0	10	40	0	0	40	0	20
N_{NO_3}, mg/m³	0	0	65	0	0	50	0	25
Peridinians	3,300	7,040	130	2,160	1,250	220	2,440	1,650
(Peridinium triquetrum)	(2,000)	(5,600)	(20)	(550)	(550)	(60)	(360)	(150)
Diatoms	340	260	630	60	400	2,940	..	60
Coccolithophorides	4,410	11,000	8,400	40,420	30,420	16,810	5,250	5,600
(Pontosphaera huxleyi)	(3,600)	(8,600)	(400)	(37,200)	(29,600)	(16,800)	(5,200)	(5,600)
Flagellates	96,400	130,400	10,800	94,510	57,640	36,010	210,260	68,000
Infusorians	260	510	150	870	630	90	470	70

[1]) For as Hentschel (1933) states, an abundance of small heterotrophic flagellates follows after a rich diatom plankton.

Of the many species of peridinians, only *Peridinium triquetrum* was found in anything like large numbers. As regards production, the plankton is not particularly rich.

The stations 4453 and 4454 at Snefellsnes and Staalbjerghuk as far as the plankton is concerned, are practically at the same stage as those in the Fakse Bay (table 19). The torrent at Staalbjerghuk was now again observed and the content of nutritive salts in the surface layers was therefore fairly large here.

St. 4457 in Patrichsfjord and stations 4459 and 4460 in Ønundafjord have a mixed diatom-peridinian plankton (table 20). The quantity of plankton is, however, small; nitrates and phosphates could not be traced in the surface layers. *Peridinium triquetrum* was the most common species.

Table 20.

Plankton per 100 ccm in the fjords at the northwest corner of Iceland, July 1932.

	St. 4457 Patrichsfjord 65°34′.7 N 23°58′W $^{20}/_{7}$			St. 4459 Ønundafjord 66°03′N 23°31′W $^{21}/_{7}$		St. 4460 Mouth of Ønundafjord 66°08′ N 23°43′W $^{22}/_{7}$		
Depth in m	0	10	25	0	10	0	10	25
Temperature in ° C	10.22	9.57	9.17	10.77	8.40	8.50	8.38	8.38
Salinity, ‰	34.40	34.46	34.53	32.84	34.42	34.63	34.74	34.76
P_2O_5, mg/m³	10	10	10	10	..	..	..	..
N_{NO_3}, mg/m³	0	0	0	0	..	..	..	..
Peridinians	6,240	2,160	360	2,330	4,440	800	1,360	750
(Peridinium triquetrum)	(6,080)	(500)	(60)	(300)	(1,240)	(440)	(850)	(500)
Diatoms	4,940	8,240	2,340	7,190	9,340	12,600	20,750	8,300
(Chactoceros constrictus)	(2,800)	(3,520)	(1,400)	..	(240)	(760)	(550)	(200)
(Chaetoceros debilis)	(200)	(1,340)	..	(2,940)	(3,540)	(4,500)	(10,250)	(4,900)
(Chaetoceros contortus)	..	..	(200)	(1,330)	(840)	(1,520)	(2,050)	(520)
Coccolithophorides	..	..	..	..	..	..	..	..
Flagellates	44,060	132,020	70,440	23,780	112 780	18,800	22,800	14,420
Infusorians	20	140	220	150	30	200	150	90

Stations 4461—4464 (table 21) lie at the north-west corner of Iceland, off Cape North. A mingling of cold polar water can be distinctly traced especially at St. 4462. The polar water of the East Greenland Current is not far off. The surface water is stabilized and without determinable quantities of nutritive salts. The quantitatively very rich plankton, however, indicates that the phosphates and nitrates have only very recently disappeared from the surface layers. The appearance of resting spores among the several *Chaetoceros* species and the obvious sinking of the plankton at Stations 4462 and 4464 are evidence that the production has culminated. It is, however, not a question of the last remnants of the spring maximum — the stations were taken at the end of July — but on the contrary of a second maximum due presumably to the mingling of water, rich in nutrition, from the Denmark Strait.

It is a typical diatom plankton consisting principally of *Chaetoceros* species, for instance: — *C. debilis*, *C. contortus*, *C. laciniosus* and *C. furcellatus*, but of many different other diatoms besides, of which quite a number were found in considerable quantities. The same peridinian species which, further to the south, dominate in the plankton were also found in the samples off Cape North; but though they were found in about the same proportion, as regards quantity,

	St. 4461 66°53′ N 23°40′ W 23/7				St. 4462 66°36′ N 23°54′ W 23/7				St. 4463 66°30′ N 23°00′ W 23/7				St. 4464 66°41′ N 23°09′ W 23/7			
Depth in m	0	10	25	50	0	10	25	50	0	10	25	50	0	10	25	50
Temperature in ° C	7.84	7.61	6.38	6.44	5.03	5.11	6.11	5.92	7.96	7.54	6.67	6.50	8.06	7.95	6.57	6.00
Salinity, ‰	34.71	34.69	34.69	34.88	33.75	34.00	34.56	34.69	34.61	34.70	34.86	34.86	34.68	34.70	34.79	34.99
P_2O_5, mg/m³	5	0	20	45	..	..	..	..	0	10	40	40	0	0	15	60
N_{NO_3}, mg/m³	0	0	40	70	..	..	..	..	0	30	100	100	0	0	40	160
Peridinians	3,900	3,280	1,200	1,270	6,050	6,900	600	50	10,900	4,450	1,450	80	4,200	2,090	2,000	360
(Peridinium triquetrum)	(2,500)	(2,100)	(200)	..	(2,500)	(300)	(100)	..	(6,600)	(3,000)	(100)	..	(3,000)	(850)	(800)	(40)
Diatoms	106,600	58,160	57,300	1,670	7,900	48,200	63,600	2,700	119,800	83,900	75,250	13,960	71,600	84,430	197,900	15,940
(Chaetoceros contortus)	(4,500)	(5,400)	(1,000)	(160)	..	(2,100)	(1,000)	..	(41,300)	(24,000)	(15,000)	(900)	(31,000)	(36,500)	(15,500)	(120)
(Chaetoceros laciniosus)	(21,500)	(10,080)	(4,500)	(90)	..	(300)	(2,900)	(80)	(3,000)	(300)	(300)	..	(2,000)	(1,900)	(10,400)	(640)
(Chaetoceros debilis)	(19,000)	(12,800)	(20,000)	(40)	(7,500)	(36,500)	(9,000)	(320)	(44,000)	(30,500)	(34,000)	(7,000)	(21,000)	(31,300)	(73,500)	(1,460)
(Chaetoceros furcellatus)	(8,600)	(2,280)	(5,700)	(190)	..	(400)	(4,300)	(70)	(5,100)	(6,000)	(4,500)	(1,600)	(700)	(1,050)	(3,700)	(2,000)
(Nitzschia delicatissima)	(31,500)	(21,600)	(20,500)	(420)	(250)	(2,700)	(15,000)	(440)	(8,400)	(6,300)	(8,500)	(2,800)	(4,300)	(4,400)	(61,000)	(5,600)
Coccolithophorides	200	20	..	..	1,400	1,500	..	20	..	..	..	..	800	..	500	..
(Coccolithus pelagicus)	..	(20)	..	..	(1,400)	(1,500)	..	(20)	..	..	..	..	..	..	..	..
Flagellates	41,100	34,420	20,000	9,200	38,400	72,800	22,900	9,200	76,200	44,050	38,550	15,200	50,600	49,820	27,400	11,600
Infusorians	..	..	100	10	500	800	300	10	700	200	200	20	550	410	400	..

Table 22.

Plankton per 100 ccm at the north coast of Iceland, end of July 1932.

	St. 4465 66°17′ N 20°16′ W 23/7				St. 4466 Siglunes, outer St. 66°32′ N 18°50′ W 24/7				St. 446E Siglunes, inner 66°16′ N 18°50′ W 24/7				St. 4469 66°30′ N 17°17′ W 25/7			
Depth in m	0	10	25	50	0	10	25	50	0	10	25	50	0	10	25	50
Temperature in ° C	6.91	6.36	5.14	4.89	7.08	6.99	4.84	4.88	5.43	5.27	5.07	4.08	6.89	6.66	5.83	3.53
Salinity, ‰	34.16	34.19	34.52	34.78	33.95	33.93	34.34	34.93	34.12	34.14	34.46	34.61	33.89	33.90	34.03	34.61
σ_t	26.80	26.89	27.30	27.54	26.60	26.60	27.30	27.65	26.95	26.98	27.25	27.49	26.58	26.62	26.83	27.54
P_2O_5, mg/m³	..	..	..	..	5	5	15	60	15	15	35	45	..	..	..	..
N_{NO_3}, mg/m³	..	..	..	..	0	0	35	275	25	25	50	75	..	..	..	..
Peridinians	310	140	120	70	..	10	10	50	70	50	150	70	..	..	..	20
Diatoms	80	170	370	250	120	50	90	40	470	230	40	10	30	30	60	30
(Nitzschia delicatissima)	..	(60)	(80)	(190)	(40)	(50)	(40)	(20)	(290)	(80)	(40)	..	(20)	(30)	(30)	(30)
Coccolithophorides	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Flagellates	40,000	100,000	65,000	10,800	19,600	68,000	447,000	6,000	705,000	791,000	16,000	2,800	65,000	251,000	676,000	10,200
Infusorians	330	350	50	10	..	..	..	..	70	20	40	10	20	..	20	..

they were quite lost in the vast mass of diatoms. East of Cape North, a very poor plankton was found at the end of July (table 22). This area, so poor in plankton, stretched along the entire north coast. It was not until off Riffstangi, at the northeast corner of Iceland, that a real plankton production was found, though it was not particularly vigorous (table 23).

In the area, poor in plankton, there was, however, found a large quantity of small heterotrophic flagellates, a criterion that earlier in the year a vigorous plankton production must have occurred here. The hydrographic conditions were in keeping with the poverty of the plankton. The surface water was highly stabilized and the nutritive salts had previously been consumed. Only at the innermost station of the Siglunes section, St. 4468, were nitrates and phosphates found in the surface layers. This together with the -- as compared with the neighbouring stations -- fairly cold surface temperature indicates upwelling of deep water.

The small plankton maximum at Riffstangi must be due to a supply of nutritive deep-water either on account of the supply in the tide races which according to "Den Islandske Lods" 1911 are generally powerful here or by a blending of water from the East Icelandic Current (vide chapter VII). The nutritive salts had, however, practically speaking disappeared from the surface layers and the plankton was just about beginning to sink. The dominating species were the diatoms *Eucampia groenlandica*, *Nitzschia delicatissima*, *Sceletonema costatum* and *Thalassiosira sp.*

Table 23.

Plankton per 100 ccm at the northeast corner of Iceland, end of July 1932.

	St. 4470 66°35′ N 16°10′ W $^{25}/_{7}$				St. 4471 66°42′ N 16°10′ W $^{25}/_{7}$				St. 4474 66°22′ N 14°27′ W $^{26}/_{7}$			
pth in m	0	10	25	50	0	10	25	50	0	10	25	50
mperature in ° C	6.89	4.77	2.03	1.73	6.88	6.62	3.72	2.15	4.02	3.63	2.49	2.17
nity, ‰	33.00	33.75	34.29	34.33	33.25	33.25	34.02	34.33	34.13	34.14	34.24	34.34
	25.88	26.73	27.42	27.47	26.07	26.11	27.06	27.44	27.11	27.17	27.34	27.45
P_5, mg/m³	0	0	50	60	0	0	15	50	30	30	50	55
O_2, mg/m³	..	..	..	..	..	..	..	..	..	..	..	..
idinians	60	340	10	..	80	60	..	..	..	20	40	50
toms	1,650	14,700	290	50	19,330	20,020	37,200	90	..	..	50	40
Sceletonema costatum)	..	(160)	..	..	(4,000)	(4,000)	(6,400)	..	..	..	..	..
Thalassiosira sp.)	(80)	(1,420)	(10)	..	(1,600)	(800)	(7,200)	..	..	..	..	..
Eucampia groenlandica)	(1,200)	(9,860)	(10)	(10)	(10,400)	(8,400)	(5,600)	..	..	..	..	..
Nitzschia delicatissima)	(370)	(3,120)	(90)	(10)	(2,400)	(4,000)	(11,200)	(30)	..	..	(20)	(10)
colithophorides	..	..	..	..	..	..	..	..	..	..	..	..
gellates	42,800	105,200	29,600	2,800	92,000	112,000	188,000	14,000	74,000	86,000	41,000	10,400
isorians	30	70	..	10	40	50	..	30	10	40	30	50

St. 4474 at Langanes is situated in the middle of the well known powerful tide race here. Therefore nitrates and phosphates are found in the surface layers but on the contrary only a small quantity of plankton, flagellates excepted (table 23).

At Langanes the current turns to the south and continues along the east coast of Iceland. Yet the arctic water coming from the north soon gets the upperhand of the actual coast water. The arctic current which presumably on its way over the Icelandic shelf was exposed to vertical

movements, is fairly rich in nutritives, but the commencement of a plankton production was not found until so far south as at St. 4480 (table 24). It was the oceanic species *Fragilaria nana* that dominated.

Table 24.

Plankton per 100 ccm at the east coast of Iceland, end of July 1932.

	St. 4476 65°40′ N 14°10′W 26/7			St. 4479 65°19′.5 N 13°34′W 29/7			St. 4480 64°58′ N 13°26′W 29/7			
Depth in m	0	10	25	0	10	25	0	10	25	50
Temperature in ° C.	6.89	6.53	5.03	6.13	5.93	5.60	5.41	5.30	5.21	4.97
Salinity, ‰	32.84	33.50	33.98	32.62	33.14	33.60	34.01	34.01	34.01	34.09
σ_t	25.72	26.32	26.88	25.68	26.11	26.52	26.86	26.88	26.89	26.98
P_2O_5, mg/m³	5	..	..	15	10	10	..	..	..	..
N_{NO_3}, mg/m³	0	..	..	25	25	35	..	..	..	..
Peridinians	..	..	30	..	10	10	..	30	10	20
Diatoms	..	..	10	..	140	250	11,200	6,050	7,600	6,010
(Thalassiosira spec.)	..	..	...	..	30)	(30)	(800)	(800)	1,200	400
(Nitzschia delicatissima)	..	..	(30)	..	..	(30)	(800)	(50)	..	(10)
(Fragilaria nana)	..	..	..	..	(100)	(170)	(9,600)	(5,200)	(6,400)	(5,600)
Coccolithophorides	..	..	..	..	10	..	110	160	80	120
Flagellates	28,800	24,400	12,600	52,000	88,000	..	72,000	81,000	84,000	82,000
Infusorians	10	..	60	..	40	20	80	130	30	..

Table 25.

Plankton per 100 ccm in Seydisfjord, end of July 1932.

	St. 4477 65°15′.8 N 14°00′.5 W 28/7		St. 4478 65°18′ N 13°53′W 29/7		
Depth in m	0	10	0	10	25
Temperature in ° C.	8.00	6.15	6.54	5.83	5.11
Salinity, ‰	27.48	32.40	31.93	32.67	33.84
P_2O_5, mg/m³	0	5	5	10	25
N_{NO_3}, mg/m³	0	20	0	30	40
Peridinians	30	50	80	30	10
Diatoms	58,500	16,100	21,100	370	90
(Thalassiosira sp.)	(1,200)	(1,200)	(1,200)	(40)	..
(Chaetoceros debilis)	(53,600)	(10,100)	(14,000)	(230)	..
(Eucampia groenlandica)	(1,200)	(1,600)	(2,400)	(20)	..
(Nitzschia delicatissima)	(1,200)	(1,600)	(2,800)	(70)	..
Coccolithophorides	..	..	..	10	..
Flagellates	88,000	204,000	136,000	24,400	..
Infusorians	150	300	90	60	..

Large quantities of plankton were found in Seydisfjord (table 25). The plankton production here is presumably dependent on the supply of nutritive salts by the tidal currents from without.

This large production has the effect, however, that, as a rule, no nitrates and phosphates are found in the surface layers. Besides a large quantity of presumably heterotrophic flagellates, the plankton consisted principally of the diatom *Chaetoceros debilis*.

As usual the boundary line between the cold arctic water and the warm Atlantic coastal water lay between Eystra- and Vestrahorn. Stations 4482 - 4484 lie in this transitional area (table 26). The very large quantities of plankton point to a very vigorous production.

By the mixing processes which doubtless occur spasmodically and not continuously, nutritive-bearing deep water comes to the surface. When a somewhat calm state is again attained, a vigorous plankton production occurs by which the nutritive salts in the surface layers are consumed. When stations 4482—4484 were taken there was only a small quantity of nitrates and phosphates in the surface layers. The plankton consisted mostly of diatoms, especially *Chaetoceros furcellatus* and *Sceletonema costatum*. Moreover the coccolithophorid *Pontosphaera huxleyi* appeared in fairly large numbers in the samples from 10 and 25 m.

Table 26.

Plankton per 100 ccm in the mixing area at the east coast of Iceland, end of July 1932.

	St. 4482 64°22′ N 14°24′ W $^{29}/_{7}$				St. 4483 64°12′ N 14°53′ W $^{29}/_{7}$				St. 4484 64°05′ N 15°31′ W $^{29}/_{7}$			
th in m	0	10	25	50	0	10	25	50	0	10	25	50
perature in ° C	5.88	5.73	5.17	5.27	6.78	6.01	7.24	7.20	8.87	9.32	9.32	8.32
nity, ‰	33.86	33.98	34.04	34.22	33.40	33.73	34.25	34.60	32.98	33.82	34.26	34.96
	26.75	26.78	26.91	26.99	26.27	26.57	26.81	27.10	25.58	26.16	26.41	27.08
$_6$, mg/m³	..	..	..	..	10	20	15	40	5	10	10	50
O_2, mg/m³	..	..	..	..	5	50	25	80	0	0	5	150
dinians	1,240	560	60	10	2,150	800	5,120	270	7,200	5,800	3,800	240
oms	94,480	105,700	26,600	4,520	575,000	279,000	34,300	1,900	29,300	12,160	24,000	410
celetonema costatum)	(12,000)	(8,400)	(2,200)	(570)	(69,600)	(51,600)	(2,400)	..	(2,400)	(2,000)	(15,200)	(240)
eptocylindrus minima)	(4,400)	(2,400)	(4,400)	(70)	(13,200)	(12,800)	(2,000)	..	(5,200)	(3,200)	(760)	..
haetoceros furcellatus)	(58,400)	(78,000)	(12,600)	(770)	(434,000)	(184,000)	(4,800)	(140)	(8,000)	(3,200)	(1,960)	(130)
haetoceros similis) ...	(3,900)	(3,200)	(920)	(20)	(22,400)	(13,600)	(800)	..	(10,800)	(1,620)	(660)	..
Nitzschia delicatissima)	(400)	(2,000)	(2,400)	(400)	(1,600)	(7,200)	(1,600)	..	(400)	(500)	(4,000)	(40)
colithophorides	800	2,800	400	1,600	..	1,200	14,060	8,800	8,800	10,420	37,240	1,600
Pontosphaera huxleyi)	(800)	(2,800)	(400)	(1,600)	..	(1,200)	(14,000)	(8,800)	(8,800)	(10,400)	(37,200)	(1,600)
ellates	28,800	54,000	31,600	17,000	42,400	21,600	48,000	8,000	32,800	19,600	54,400	12,400
sorians	100	160	140	..	1,450	100	80	10	1,100	560	140	20

At Vestrahorn, Iceland was left behind and the course was laid towards the Faroes. Stations 4486—4488 lie over the submarine ridge between Iceland and the Faroes (table 27). A slight mixture of arctic water is to be noticed at St. 4487 where the salinity is below 35.10 and the temperature is lower than 10° C. at the surface. St. 4488, on the other hand, lies in pure Gulf Stream water. At St. 4486 the influence of the coast makes itself felt. The considerable quantities of nutritive salts in the surface layers indicate a mixture of deep water. This mingling is particularly characteristic at St. 4487, where the surface water was undersaturated with oxygen.

The plankton is somewhat rich. Of the many naked flagellates, doubtless no small

Table 27.

Plankton per 100 ccm over the ridge between the Faroes and Iceland, end of July 1932.

	St. 4486 64°00′ N 15°06′ W 29/7			St. 4487 63°25′ N 12°03′ W 30/7				St. 4488 62°42′ N 8°40′ W 30/7
Depth in m	0	10	25	0	10	25	50	0
Temperature in ° C	10.71	10.78	10.77	9.50	9.38	9.30	8.92	11.60
Salinity, ‰	35.12	35.18	35.20	35.07	35.08	35.08	35.11	35.28
σ_t	26.94	26.97	26.99	27.11	27.14	27.15	27.23	26.90
P_2O_5, mg/m³	..	..	..	30	30	30	40	10
N_{NO_3}, mg/m³	..	..	..	75	60	60	90	50
O_2, perc. of sat.	..	..	..	98.4	..	98.0	96.0	100.0
Peridinians	9,160	9,860	9,790	1,750	1,250	1,130	180	18,080
Diatoms	3,210	2,330	6,210	3,530	3,200	2,510	2,780	480
(Fragilaria nana)	(1,200)	(800)	(4,800)	(2,800)	(2,400)	(1,600)	(2,000)	..
(Nitzschia delicatissima)	(710)	(620)	(1,000)	(380)	(420)	(390)	(480)	(50)
Coccolithophorides	38,460	26,120	24,530	7,220	3,340	5,360	2,090	4,870
(Pontosphaera huxleyi)	(36,400)	(24,800)	(23,200)	(7,200)	(3,200)	(5,200)	(2,000)	(4,000)
Flagellates	85,200	72,400	78,400	29,600	23,200	10,800	8,000	32,000
Infusorians	380	400	110	100	170	90	70	70

numbers were autotrophic. Besides these, there were found, especially, the coccolithophorid *Pontosphaera huxleyi*, several small gymnodinians and the diatom *Fragilaria nana*.

At St. 4489 we have again reached the coastal area off the Faroes. Just as we did six weeks ago, we now find a vigorous plankton production here, the result of a strong vertical mixing whereby nitrates and phosphates are continuously carried up to the surface (further particulars are given on page 59).

It is particularly the *Chaetoceros* species that is now predominent in the plankton, above all *C. debilis* and *C. contortus*.

As it was in the middle of June *Nitzschia delicatissima* is again present in large quantities. *Rhizosolenia faeroense*, on the contrary, has almost entirely disappeared from the plankton (table 28).

The plankton in the fjords is exactly similar to that in the coastal waters proper. This was to be expected in a fjord like Vaagfjord, where there is a very vigorous exchange of water. When also in the threshold fjord Skaalefjord, where the plankton in June was very poor, there is now found a plankton which qualitatively and quantitatively corresponds exactly to the plankton outside, it must be due to a fresh interchange with the outside water.

Finally, St. 4508 was taken in the middle of the Faroe-Shetland channel. Here we find a typically oceanic plankton in fairly large quantities (table 57, appendix) The coccolithophorids *Pontosphaera huxleyi* and *Syracosphaera* spec. together with the diatom *Fragilaria nana* are the dominating species. Though the surface water was distinctly stabilized, the nutritive salts were present there in fairly large quantities. Questions regarding the production in the Channel area will be more closely gone into in chapter VII.

As it was expedient to treat the plankton conditions at Iceland consecutively, the part of the July-August cruise which was made from Staalbjerghuk over the Denmark Strait, along

the coast of East Greenland and back again over the Irminger Sea to Iceland, was put off until it could be dealt with here. This part of the cruise took place between the 8th and 15th of July.

The stations 4427—4433 lie in the section over the Denmark Strait. While St. 4427 and St. 4428 were situated in the Icelandic coastal area (vide page 19, table 17) St. 4429 lies in the mingling-area between the Gulf Stream water and the polar water (table 29). That water is here conveyed from the depths to the surface layers is made manifest by the big quantities of phosphates and the low values of the oxygen-saturation in the surface layers. Considering the quantity of phosphates, the plankton is rather poor, which, presumably, is due to the disturbed hydrographic conditions in the mingling-area. The Atlantic element dominates in the plankton, particularly the two diatoms *Nitzschia delicatissima* and *Fragilaria nana*.

Table 28.

Plankton per 100 ccm at the Faroe Island, about the 1st of August 1932.

	St. 4489 At the coast of the Faroes 62°21′ N 7°16′ W 31/7		St. 4495 Skaale-fjord 62°07′ N 6°49′.5 W 2/8	St. 4505 Vaag-fjord 61°27′.8 N 6°45′ W 7/8
Depth in m	0	50	0	0
Temperature in ° C	9.32	9.31	10.01	9.88
Salinity, ‰	35.20	35.22	34.96	35.20
σ_t	27.24	27.26	26.81	27.14
P_2O_5, mg/m³	30	35	15	30
N_{NO_3}, mg/m³	85	85	0	70
Peridinians	420	440	3,300	100
Diatoms	28,980	22,860	28,700	41,700
(Chaetoceros contortus)	(4,200)	(3,200)	(1,200)	(5,600)
(Chaetoceros debilis)	(12,000)	(8,000)	(10,000)	(21,200)
(Chaetoceros furcellatus)	(600)	(1,600)	(7,600)	(7,650)
(Nitzschia delicatissima)	(7,800)	(6,000)	(2,400)	(1,600)
Coccolithophorides	..	..	..	400
Flagellates	10,000	8,400	10,450	16,000
Infusorians	180	120	..	..

Table 29.

Plankton per 100 ccm in the mixing area in the Denmark Strait, July 1932.

	St. 4429 65°49′ N 26°37′ W 8/7		
Depth in m	10	25	50
Temperature in ° C	6.39	6.35	6.88
Salinity, ‰	34.79	34.79	35.01
σ_t	27.36	27.36	27.46
P_2O_5, mg/m³	40	45	50
O_2, perc. of sat.	95.9	..	93.8
Peridinians	210	500	500
Diatoms	2,640	11,730	3,040
(Fragilaria nana)	(1,600	(7,600)	(1,200)
(Nitzschia delicatissima)	(800)	(3,600)	(1,200)
Coccolithophorides	..	30	20
Flagellates	4,000	26,800	10,600
Infusorians	30	80	90

The stations 4430—4433 lie in the cold East Greenland Current, which is characterized by the negative temperature of the water (table 30). Right at the surface, however, owing to the summer warmth, positive temperatures are now found. At St. 4431 is to be traced a slight but distinct mixture of Atlantic water.

While at the stations 4430 and 4431 fairly large quantities of phosphates and nitrates are still found in the surface layers, the nutritive salts in these layers at the stations 4432 and 4433, have been quite used up. The low percentages of oxygen-saturation in the surface layers which are particularly conspicuous at St. 4433, where the nutritive salts have been completely used up, are perhaps a result of the mingling of oxygen lacking water from the melting sea ice. Experiments by the author have shown, that the percentage of O_2-saturation of the melting water of ice, produced by freezing O_2-saturated water, is only ca. 50.

Table 30.

Plankton per 100 ccm in the polar water in the Denmark Strait, July 1932.

	St. 4430 66°10′ N 28°00′ W			St. 4431 66°22′ N 29°20′ W				St. 4432 66°17′ N 31°00′ W				St. 4433 65°58′ N 31°50′ W			
	%			%				%				%			
Depth in m	0	10	25	0	10	25	50	0	10	25	50	0	10	25	50
Temperature in °C	0.20	−0.27	−0.08	1.14	1.20	1.46	1.22	0.60	0.68	−0.56	1.01	0.50	0.71	0.43	−1.37
Salinity, ‰	32.90	33.19	33.61	32.90	33.40	33.79	34.01	32.92	33.13	33.60	33.95	30.79	31.82	32.52	32.88
σ_t	26.43	26.68	27.03	26.37	26.77	27.06	27.26	26.42	26.58	27.00	27.28	24.71	25.58	26.10	26.41
P_2O_5, mg/m³	15	20	30	15	20	25	40	10	10	20	40	0	0	0	35
NNO_3, mg/m³	15	40	60	25	60	70	90	0	0	40	80	0	0	0	70
O_2, perc. of sat.	97.2	94.7	93.6	96.3	97.6	93.4	93.0	99.2	101.6	99.1	88.8	95.8	97.8	107.7	91.8
Peridinians	980	880	580	420	660	1,740	1,240	320	610	200	870	410	350	890	440
Diatoms	11,870	11,480	1,890	16,200	5,340	6,200	3,140	6,290	7,380	12,610	4,580	1,860	5,560	950	14,320
(Thalassiosira nordenskj.)	(320)	(640)	..	(1,260)	(100)	(100)	(40)	(660)	(570)	(40)	(180)	(210)	(150)	(30)	(200)
(Thalassiosira gravida)	(740)	(340)	(160)	(1,140)	(280)	(540)	(540)	(440)	(570)	(1,280)	(1,230)	(100)	(140)	(120)	(1,830)
(Chaetoceros furcellatus)	(7,000)	(6,800)	(170)	(11,800)	(2,300)	(160)	(180)	(2,570)	(2,660)	(770)	(250)	(150)	(4,260)	(160)	(110)
(Nitzschia delicatissima)	(40)	(260)	(500)	(120)	(160)	(1,600)	(520)	(1,290)	(2,000)	(9,600)	(2,400)	(30)	(340)	(120)	(11,600)
Coccolithophorides	20	..	..	..	..	40	20	..	30	10	..	..	..	40	10
Flagellates	25,200	17,100	5,600	12,400	8,800	9,600	6,400	55,600	145,000	883,000	286,000	4,000	6,800	8,900	(1,269,000)
(Phaeocystis pouchetii)	..	..	..	..	..	..	..	(53,200)	(140,000)	(880,000)	(284,000)	..	(800)	(900)	(1,269,000)
Infusorians	380	230	90	100	320	980	160	660	540	110	70	160	320	180	140

It is clearly to be seen at St. 4433 how the oxygen content of the upper 25 m, where the nutritive salts have been used up during the plankton production, is proportional to the amount of water from the melting ice, which is manifested by the salinity.

In relation to the content of nutritive salts, the plankton production has not yet culminated at stations 4430 and 4431 which are still rich in phosphates and nitrates while, on the contrary, this is the case at stations 4432 and 4433 where the nutritive salts in the surface layers have been used up; the large plankton values in the deep water at these stations show that the plankton is about to sink.

The composition of the plankton is to some extent the same at all the stations though perhaps the exceedingly large quantity of the autotrophic flagellate, *Phaeocystis ponchetii*, at St. 4432 and St. 4433 is the cause of the more rapid consumption of the nutritive salts here. At the other two stations this alga was not found at all. Otherwise it is diatoms that dominate in the plankton, especially *Chaetoceros furcellatus*. In addition there must be mentioned *Thallassiosira nordenskjöldii*, *Thallassiosira gravida* and *Nitzschia delicatissima*. The peridinians play but a minor part; only small gymnodinians were found in anything like considerable numbers. Coccolithophorides were observed only singly.

The stations 4434—4442 (table 31) which were taken along the ice margin southwards to 62°40′

N all lie in the mixing area between the polar and Gulf Stream waters. The content of nutritive salts in the surface layers is very different at these stations. The mingling processes are not of course equally vigorous everywhere. The plankton production is generally large at all stations, largest at those where the Atlantic water dominates. So it is in the most pronounced Atlantic water-layers that at certain stations the largest quantities of plankton are found; this is particularly noticeable at St. 4436 and St. 4442, where right at the surface over fairly pronounced Atlantic water there is almost pure polar-current water. As regards the qualitative composition of the plankton, the blending of arctic and Atlantic elements is clearly to be seen. The composition of the plankton is much the same at all the stations even though there is, of course, a pronounced difference in the proportion, as regards quantity, between the two elements, accordingly as the Atlantic or the polar water dominates. Only at stations distinctly affected by polar water, stations 4435 and 4436, was the flagellate *Phaeocystis pouchetii* found and here, moreover, in very lage quantities. Otherwise it is the diatoms which constitute the chief part of the producers of the plankton. *Nitzschia delicatissima* which is particularly characteristic of Atlantic water is the most frequent species. Of quantitatively significant, specifically Atlantic species must be mentioned *Fragilaria nana*, of polar water species particularly *Chaeto-*

Table 31 a.

Plankton per 100 ccm in the mixing area along the coast of East Greenland, July 1932.

	St. 4434 65°23′ N 32°14′W				St. 4435 65°25′ N 33°50′W				St. 4436 65°13′ N 35°15′W				St. 4436 64°48′ N 36°35′ W
	$^{10}/_{7}$				$^{10}/_{7}$				$^{10}/_{7}$				$^{10}/_{7}$
Depth in m	0	10	25	50	0	10	25	50	0	10	25	50	0
Temperature in ° C	2.40	1.92	1.36	1.51	1.50	1.59	0.78	2.13	3.96	4.49	8.24	8.23	6.64
Salinity, ‰	33.89	33.89	33.86	33.93	32.47	32.92	33.68	34.20	33.84	34.15	35.06	35.04	34.34
σ_t	27.07	27.11	27.12	27.17	26.00	26.36	27.02	27.34	26.89	27.08	27.30	27.29	26.97
P_2O_5, mg/m³	40	30	30	30	0	0	20	35	10	15	25	30	5
NNO_3, mg/m³	80	80	60	80	0	0	70	100	5	50	90	80	10
O_2, perc. of sat.	97.8	96	95.9	94.8	98.7	102.3	96.8	92.1	104.8	102.0	97.6	97.4	107.2
Peridinians	220	180	130	170	200	300	960	370	140	1,140	1,480	1,000	70
Diatoms	4,560	1,450	730	1,070	10,820	8,850	7,120	1,700	3,740	14,800	37,040	38,760	27,760
(Chaetoceros furcellatus)	..	..	(20)	..	(3,500)	(1,020)	(980)	(90)	(1,030)	(3,040)	(120)	(80)	..
(Rhizosolenia alata)	..	(10)	(10)	(50)	(160)	(160)	(50)	(120)	(80)	(360)	(1,800)	(2,080)	..
(Fragilaria nana)	(2,000)	(280)	(310)	(380)	..	..	..	(50)	..	..	(800)	(2,000)	(2,000)
(Nitzschia delicatissima)	(2,000)	(800)	(150)	(240)	(2,200)	(3,600)	(2,060)	(190)	..	..	..	..	(24,800)
Coccolithophorides	..	..	..	..	..	..	..	10	10	60	..	60	..
Flagellates	12,800	10,400	13,600	16,400	54,500	106,800	365,200	17,600	163,200	360,000	22,400	11,600	5,200
(Phaeocystis pouchetii)	..	..	..	..	(53,600)	(106,000)	(360,000)	(7,000)	(162,000)	(360,000)	(20,000)	(3,600)	..
Infusorians	90	50	110	60	180	340	250	70	220	350	520	120	90

Table 31 b.

Plankton per 100 ccm in the mixing area along the coast of East Greenland, July 1932.

	St. 4438 64°13′ N 38°15′W 11/7			St. 4440 63°22′ N 40°00′W 11/7				St. 4441 62°40′ N 40°40′W 12/7				St. 4442 62°40′ N 41°20′W 12/7			
Depth in m	0	25	50	0	10	25	50	0	10	25	50	0	10	25	50
Temperature in ° C	6.40	3.97	2.13	7.60	7.54	7.34	6.02	8.17	8.22	7.62	6.10	2.50	4.47	5.09	6.15
Salinity, ‰	33.95	34.29	34.31	34.70	34.69	34.67	34.74	35.02	35.03	34.92	34.74	31.69	33.10	33.58	34.31
σ_t	26.68	27.25	27.42	27.12	27.12	27.13	27.37	27.29	27.28	27.29	27.36	25.31	26.25	26.56	27.01
P_2O_5, mg/m³	10	20	50	20	20	20	40	35	35	35	40	10	15	20	45
N_{NO_3}, mg/m³	0	25	100	40	40	30	90	70	90	65	90	0	15	25	125
O_2, perc. of sat.	105.8	99.3	91.4	100.8	102.1	100.0	95.2	100.2	100.2	..	98.6	..	..	..	..
Peridinians	40	260	1,640	800	1,200	2,800	2,810	5,240	3,350	3,000	580	220	3,360	90	270
Diatoms	122,100	77,060	3,360	118,000	51,300	21,800	24,700	37,600	30,700	26,000	12,500	8,420	168,900	164,000	890
(Rhizosolenia alata)	..	(10)	..	..	..	..	..	(1,760)	(3,250)	(3,150)	(620)	—	(10)	(40)	(10)
(Chaetoceros furcellatus)	..	..	..	..	..	..	..	(480)	(450)	(350)	..	(10)	(40)	..	..
(Fragilaria nana)	(7,600)	(4,800)	(800)	(58,000)	(20,000)	(10,000)	(16,400)	(5,200)	(3,200)	(2,800)	(7,200)	(800)	(15,200)	(11,200)	(170)
(Nitzschia delicatissima)	(114,400)	(71,200)	(2,400)	(60,000)	(31,200)	(11,600)	(8,000)	(27,600)	(17,600)	(15,200)	(4,000)	(7,600)	(153,200)	(152,400)	(540)
Coccolithophorides	..	20	10	20	1,200	40	30	2,040	2,150	1,800	40	..	10	..	..
Flagellates	106,400	139,200	10,000	85,200	54,800	44,400	36,400	53,200	37,200	28,800	15,600	38,800	200,000	274,000	38,400
Infusorians	110	1,400	350	80	150	10	30	410	500	700	80	10	130	160	100

ceros furcellatus. With the exception of the very Atlantic affected St. 4441, where both gymnodinians and *Pontosphaera huxleyi* were found in somewhat large quantities, the peridinians and coccolithophorides were of quite a minor significance.

The stations 4443—4450 were taken in the Irminger Sea on the way back to Iceland (table 32). They all lie south of the ridge between Iceland and Greenland and in distinctly Gulf Stream water even though a slight mixture of water of a lower salinity can be traced at all stations; towards the west the blending is most noticeable.

Nitrates and phosphates are found in fairly large quantities also in the surface water.

As the spring maximum for the plankton began later in the Irminger stream than in the North Atlantic (to be dealt with later on) the large quantities of nutritive salts, now in the middle of July, are merely a manifestation of the fact that the Spring maximum has not yet culminated; on the other hand nutritive salts may to a certain extent — as will be made clear in chapter VII — undoubtedly be conveyed to the surface layers of the Irminger Current throughout the entire summer.

It was a distinctly diatom plankton that was now found here. It is especially the small species *Nitzschia delicatissima* and *Fragilaria nana* that dominate numerically. The quantity of plankton is exceedingly large. The Peridinians play, on the whole, a minor part as likewise do the coccolithophorides which were found at the rate of only a few thousand per 100 ccm.

Of the uniformly numerous small naked Flagellates a good many were presumably autothropic.

3. July-August cruise 1933.

The cruise in 1933 took place a month later than that in 1932. The route taken by the "Dana" was, however, in the opposite direction to that of the year before, as she now began the investigations around Iceland at the east coast and proceeded round the north of the island in order, after that, to make a cruise over to East Greenland and follow the East Greenland Current down to Cape Farewell. From here a section was made over to Reykjavik and finally a range of stations was taken off the south coast of Iceland between Reykjanes and Portland.

The investigations off the east coast of Iceland were, owing to the direction of the cruise, made somewhat about the same time as in 1932; the investigations off East Greenland and in the Irminger Sea about a month later and off the south coast of Iceland two months later than in 1932. In 1933 there were no plankton investigations made off the Faroes.

St. 4588 (table 33) was taken over the ridge between the Faroes and Iceland, fairly close to the latter. The plankton here corresponds, as in 1932, to the North Atlantic summer plankton; it is rich owing to the vertical mixing. The coccolithophoride *Pontosphaera huxleyi* was found in very large quantities. The oceanic diatoms *Nitzschia delicatissima* and *Fragilaria nana* were present only in rather inconsiderable numbers; of the numerous small flagellates a very considerable part was autotrophic (*Carteria* sp.) Phosphates, but not nitrates, have disappeared from the surface layers, but as already remarked the admixture of the richly nutritive deep-

Table 32.

Plankton per 100 ccm in the Irminger Sea, July 1932.

	St. 4443 63°11′ N 39°03′W 12/7			St. 4445 64°09′ N 34°25′W 13/7				St. 4447 64°38′ N 30°10′W 14/7				St. 4450 64°37′ N 26°45′W 15/7			
Depth in m	10	25	50	0	10	25	50	0	10	25	50	0	10	25	50
Temperature in °C	8.99	8.22	8.02	8.60	8.51	8.26	7.72	9.13	9.18	8.48	8.03	8.88	8.68	8.67	7.80
Salinity, ‰	35.05	35.03	35.01	35.05	35.06	35.09	35.10	35.04	35.06	35.08	35.08	35.10	35.08	35.09	35.11
P_2O_5, mg/m³	20	20	40	35	35	35	40	20	10	30	40	20	30	40	40
N_{NO_3}, mg/m³	80	80	90	100	100	125	150	90	75	90	90	90	90	85	150
Peridinians	4,000	7,000	2,060	2,130	3,040	2,760	310	1,180	1,320	920	350	1,090	1,070	1,040	670
Diatoms	11,380	37,200	15,120	21,730	36,580	40,780	320	126,200	133,800	146,800	1,750	137,700	82,080	92,500	12,650
(Rhizosolenia alata)	(940)	(620)	(1,440)	(1,620)	(2,850)	(4,300)	(90)	(60)	(80)	(100)	(130)	(30)	(40)	(10)	(730)
(Fragilaria nana)	(1,600)	(7,600)	(1,200)	(6,400)	(7,200)	(1,200)	..	(1,200)	(2,000)	(2,400)	(160)	(80,800)	(33,200)	(37,200)	(800)
(Nitzschia delicatissima)	(4,600)	(18,400)	(12,000)	(10,600)	(24,000)	(32,600)	(180)	(123,000)	(129,600)	(140,800)	(1,250)	(56,400)	(48,400)	(54,800)	(9,600)
Coccolithophorides	2,420	9,620	420	2,040	1,200	400	420	..	..	..	420	2,440	1,240	60	50
(Pontosphaera huxleyi)	(2,400)	(9,600)	(400)	(2,000)	(1,200)	(400)	(400)	..	..	..	(400)	(2,400)	(1,200)	..	..
Flagellates	67,600	97,600	65,200	11,210	15,600	15,200	2,400	9,600	14,800	10,000	9,200	107,600	157,000	116,000	58,000
Infusorians	300	240	140	250	400	500	20	200	380	80	50	40	20	80	150

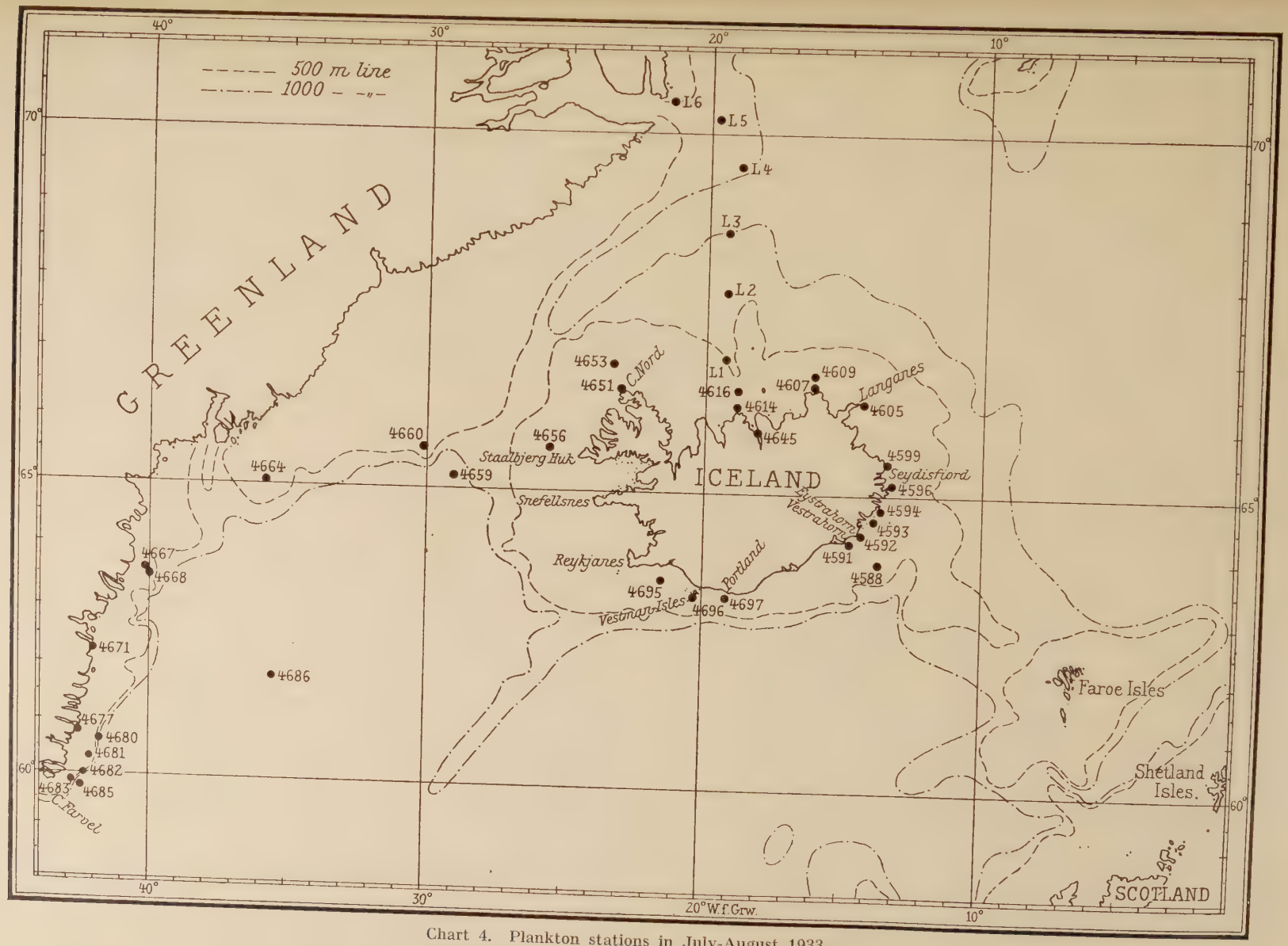

Chart 4. Plankton stations in July-August 1933.

Table 33.

Plankton per 100 ccm over the ridge between Iceland and the Faroes and in the mixing area at the east coast of Iceland, end of July 1933.

	St. 4588 Over the ridge between Iceland and the Faroes 63°56′ N 13°14′W 28/7				St. 4591 Mixing area at the east coast of Iceland 64°13′ N 14°48′W 28/7			
Dept in m	0	10	25	50	0	10	25	50
Temperature in ° C	10.92	10.74	8.71	8.10	10.32	10.58	8.72	7.82
Salinity, ‰	34.99	34.98	34.97	35.16	33.13	34.54	34.70	35.08
σ_t	26.80	26.82	27.16	27.33	25.45	25.70	26.95	27.45
P_2O_5, mg/m³	0	0	40	55	0	0	20	55
N_{NO_3}, mg/m³	10	20	>70	>70	0	0	65	>70
Peridinians	4,110	4,110	810	..	2,360	3,040	70	50
(Exuviaella baltica)	(2,400)	(1,600)	(400)	..	(480)	(800)	(20)	..
Diatoms	2,470	2,830	1,570	10	148,400	45,800	670	100
(Chaetoceros compressus)	..	..	(380)	..	(82,400)	(14,600)	..	..
(Asterionella japonica)	..	..	(170)	..	(44,000)	(3,360)	..	..
(Nitzschia delicatissima)	(1,200)	(1,200)	(400)	..	(3,600)	(2,000)	(10)	(40)
(Fragilaria nana)	(400)	(800)	..	..	..	..	..	..
Coccolithophorides	114,060	131,000	34,400	2,010	34,000	148,400	62,010	800
(Pontosphaera huxleyi)	(114,00)	(129,600)	(34,400)	(2,000)	(34,000)	(148,400)	(62,000)	(800)
Flagellates	53,600	51,600	14,400	10	30,400	73,600	24,800	2,000
Infusorians	50	40	10	30	40	120	30	..

water with the surface layers presumably takes place here intermittingly. The richness of the plankton points also to both nitrates and phosphates having been present in the surface layers quite recently.

As in 1932, the boundary line between the warm Atlantic coastal water and the East Icelandic Current lay between Eystra and Vestrahorn. St. 4591 lies off Vestrahorn and in typical Atlantic coastal water (table 33). Though neither nitrates nor phosphates could be traced in the surface water, the large quantities of plankton showed that these salts must, very recently, have been present here: also here the admixture of the nutritive salts occurs intermittingly. The plankton consists mostly of diatoms: – *Chaetoceros compressus* and *Asterionella japonica* were found in very large quantities. The coccolithophoride *Pontosphaera huxleyi* had its maximum in the deeper more salty water, a common phenomenon when this species is found in the coastal area by Iceland (see page 18).

The boundary line between the warm and the cold water was very sharp, almost typical East Icelandic Current water being found already at St. 4592 off Eystrahorn (table 34). The occurrence of the warm water species *Asterionella japonica* at St. 4592 and also further north at St. 4593 shows, however, that a smaller admixture of Atlantic water must have occurred here. A distinct vertical mixing is characteristic of Stations 4592, 4593 and 4594; this manifests itself through the even distribution of the nutritive salts and plankton in all depths (table 34). The quantity of nutritive salts at St. 4594 was not determined. Probably owing to the less stabilized conditions the plankton production is not particularly vigorous, at any rate not as

Table 34.

Plankton per 100 ccm in the Arctic water at the east coast of Iceland, end of July 1933.

	St. 4592 64°22′ N 14°22′ W 28/7			St. 4593 64°37′ N 13°55′ W 28/7			St. 4594 64°46′ N 13°40′ W 28/7			
Depth in m	0	25	50	0	25	50	0	10	25	50
Temperature in ° C	6.66	6.43	6.47	6.36	5.78	5.68	6.30	5.73	5.47	5.36
Salinity, ‰	34.40	34.43	34.47	34.43	34.46	34.48	34.47	34.47	34.51	34.51
σ_t	27.01	27.07	27.09	27.08	27.17	27.20	27.12	27.19	27.25	27.26
P_2O_5, mg/m³	30	30	30	15	15	15	..	..	..	..
N_{NO_3}, mg/m³	>50	>50	>50	60	60	60	..	..	..	..
Peridinians	110	90	..	100	30	..	160	60	180	400
Diatoms	4,650	3,400	2,400	11,960	11,860	12,760	8,800	3,660	4,030	4,400
(Thalassiosira sp.)	(2,400)	(800	(800)	(10,000)	(4,800)	(4,400)	(2,000)	(800)	(800)	(1,200)
(Asterionella japonica)	(180)	(250)	..	(1,100)	(1,900)	(5,140)	..	..	..	..
(Nitzschia delicatissima)	(20)	(120)	..	(110)	(40)	(180)	(4,400)	(2,800)	(2,400)	(2,000)
Coccolithophorides	..	..	..	..	..	..	..	800	..	400
Flagellates	43,200	38,800	22,800	17,200	24,400	16,800	71,200	57,600	36,000	24,800
Infusorians	30	90	..	40	20	..	30	50	60	..

compared with the vigorous production found here in 1932. Of the producers must especially be mentioned a little *Thalassiosira* species which was found in numbers up to 10,000 100 ccm.

Besides the conditions at East Iceland now differ, hydrographically, a great deal from those that prevailed here in 1932 as an actual admixture of arctic water to the surface layers does not occur until so far south as St. 4594 off Kambanes. At the more northerly stations 4596 and 4599

Table 35.

Plankton per 100 ccm in the coast water, warmed by the summer, at the east coast of Iceland, end of July 1933.

	St. 4596 65°10′ N 13°23′ W 29/7			St. 4599 65°30′ N 13°34′.5 W 29/7			
Depth in m	0	25	50	0	10	25	45
Temperature in ° C	8.69	8.46	4.33	9.44	9.43	8.05	6.02
Salinity, ‰	33,86	33,93	34,69	34,00	34,00	34,27	34,45
P_2O_5, mg/m³	..	..	..	0	0	0	0
N_{NO_3}, mg/m³	..	..	..	0	0	15	45
Peridinians	1,610	1,410	800	1,340	1,240	1,470	450
Diatoms	400	1,600	..	2,000	840	1,600	400
(Thalassiosira sp.)	..	(1,200)	..	(400)	(40)	..	..
(Nitzschia delicatissima)	(400)	(400)	..	(1,600)	(400)	(1,600)	(400)
Coccolithophorides	2,000	..	..	1,600	1,600	..	30
Flagellates	165,000	88,800	9,200	33,600	34,800	52,800	17,200
Infusorians	30	120	..	10	60	50	10

the surface water consists, on the contrary, of typical coastal water warmed by the summer and poor in nutritives originating presumably from the north coast (table 35). The plankton at these two stations is very poor except for small naked flagellates of which, however, the greater part is autotrophic (*Phaeocystis*).

At Langanes, where in 1932 vertical mixing was observed, the surface water was now over 9° C. and effectively stabilized (St. 4605). The tide race at Langanes is not constant. The content of smaller quantities of nutritive salts in the surface layers (table 36) and the rich plank-

Table 36.

Plankton per 100 ccm at the northeast corner of Iceland, end of July 1933.

	St. 4605 Off Langanes 66°22′ N 14°27′ W $^{30}/_{7}$				St. 4607 Off Riffstangi I 66°35′ N 16°10′ W $^{30}/_{7}$			St. 4609 Off Riffstangi II 66°49′ N 16°10′ W $^{31}/_{7}$			
Depth in m	0	10	25	50	0	10	25	0	10	25	50
Temperature in ° C	9.37	8.98	7.53	6.66	10.28	9.76	7.96	10.81	10.74	7.51	5.86
Salinity, ‰	34.41	34.42	34.57	34.76	33.22	34.04	34.57	34.63	34.67	34.83	34.95
σ_t	26.61	26.69	27.02	27.30	25.53	26.28	26.99	26.54	26.59	27.23	27.55
P_2O_5, mg/m³	10	10	15	15	5	5	5	0	0	0	45
N_{NO_3}, mg/m³	10	5	20	25	0	0	0	0	0	0	80
Peridinians	4,190	3,930	1,660	..	1,870	1,850	270	11,180	7,620	7,160	80
Diatoms	55,610	44,430	18,070	23,200	9,040	13,330	3,200	30,890	48,200	30,160	3,100
(Sceletonema costat.)	(3,600)	(800)	(800)	(1,600)	(800)	(4,400)	..	(400)	..	..	..
(Nitzschia delicatiss.)	(48,800)	(41,200)	(17,200)	(20,800)	(6,400)	(7,200)	(2,800)	(29,600)	(47,200)	(29,200)	(2,400)
(Nitzschia closterium)	(2,400)	(2,400)	..	(800)	(1,600)	(1,600)	(400)	(800)	(800)	(400)	(400)
Coccolithophorides	1,210	800	400	800	10	400	130	..	40	..	80
Flagellates	41,600	49,600	26,800	8,400	18,400	16,400	18,800	18,400	47,200	46,600	5,600
Infusorians	60	40	..	..	20	10	170	140	120	100	60

Table 37.

Plankton at the north coast of Iceland, August 1933.

	St. 4614 66°16′ N 18°50′ W $^{1}/_{8}$			St. 4616 66°32′ N 18°50′ W $^{1}/_{8}$			
Depth in m	0	25	50	0	10	25	50
Temperature in ° C	10.87	8.00	7.06	9.02	9.40	6.03	5.57
Salinity, ‰	33.53	34.74	34.81	33.77	34.14	34.56	34.88
P_2O_5, mg/m³	0	15	25	0	0	0	40
N_{NO_3}, mg/m³	0	15	40	0	0	0	60
Peridinians	830	1,600	10	3,520	2,870	2,080	2,450
Diatoms	400	30	90	2,930	1,600	3,950	3,070
(Nitzschia delicatissima)	(400)	(30)	(50)	(1,600)	(1,400)	(3,600)	(2,800)
Coccolithophorides	..	30	20	40	400	12,590	11,270
Flagellates	16,800	38,100	800	10,800	26,800	12,800	10,800
Infusorians	110	..	30	..	30	30	20

ton show, however, that an admixture of richly nutritive water must recently have taken place. Likewise at the neighbouring stations off Riffstangi a rich plankton was found (St. 4607 and St. 4609); at both places it was *Nitzschia delicatissima* that dominated.

On the whole the state of the production off the north coast of Iceland is now quite similar to what prevailed here at the same time the year previous, also at Stations 4614 and 4616, outside Siglunes, a poor plankton was now found; this is in keeping with the lack of nitrates and phosphates in the surface layers (table 37). The peridinians were generally the most numerous, small gymnodinians being found at the rate of a few thousand specimens per 100 ccm. At the outside station a little indeterminate coccolithophoride was found in comparatively considerable quantities in the samples from 25 and 50 m.

St. 4645, table 75, appendix, shows a typical state of affairs in a fjord during summer. Probably owing to the supply of nutritive salts brought by fresh water from the land it is possible for a fairly rich plankton (the diatom *Sceletonema costatum*) to exist right at the surface. As no vertical circulation can occur in the sheltered fjord owing to the calm conditions, we find the production restricted to the uppermost surface water; at a depth of 10 m we find already, that the *Sceletonema* are present only in minimal numbers.

At the north-west corner of Iceland rather small quantities of plankton were found and no nutritive salts could be traced in the surface waters. Whether a summer maximum similar to that which was shown to have occurred here in 1932, was repeated in 1933, cannot be determined. Stations 4651 and 4653 (table 38) were taken in the middle of August. Peridinians, small gymnodinians and *Peridinium triquetrum* — and the coccolithophoride *Pontosphaera huxleyi* dominated in the plankton; diatoms were generally found only in small quantities.

Table 38.

Plankton per 100 ccm at the northwest corner of Iceland, August 1933.

	St. 4651 66°30′ N 23°00′W $^7/_8$				St. 4653 66°53′ N 23°18′W $^7/_8$			
Depth in m	0	10	25	43	0	10	25	50
Temperature in ° C	11.17	11.00	10.22	10.20	7.35	8.68	4.63	5.68
Salinity, ‰	34.33	34.42	34.67	34.68	33.81	34.29	33.95	34.87
P_2O_5, mg/m³	0	0	5	10	..	..	..	..
Peridinians	5,620	2,000	340	170	570	520	360	70
(Peridinium triquetrum)	(1,790)	(1,020)	(170)	(70)	..	..	..	..
Diatoms	4,030	2,070	1,230	320	60	60	120	860
(Chaetoceros gracilis)	(2,400)	(800)	(70)	(50)	..	..	..	..
Coccolithophorides	5,200	6,000	1,200	2,000	1,210	2,020	1,700	50
(Pontosphaera huxleyi)	(4,400)	(6,000)	(1,200)	(2,000)	(1,200)	(2,000)	(800)	..
Flagellates	36,480	27,660	4,430	7,250	18,000	39,600	24,800	1,200
Infusorians	70	20	30	..	120	50	80	..

The cruise to the East Greenland waters was made from the north-west corner of Iceland; the route corresponds only partially to that taken the year before, being now a deal further south. St. 4656 (depth 234 m.) lies probably in the branch of the Irminger Current which penetrates into the Norwegian Sea over the submarine ridge between Iceland and Greenland.

Table 39.

Plankton per 100 ccm in the Irminger Current in the Denmark Strait, August 1933.

	St. 4656 65°40′ N 25°33′ W 8/8				St. 4659 65°10′ N 29°00′ W 8/8			
Depth in m	0	10	25	50	0	10	25	50
Temperature in ° C	11.50	11.48	11.09	7.81	11.31	11.30	11.29	8.70
Salinity, ‰	35.00	35.00	35.00	35.11	35.04	35.03	35.01	35.10
σ_t	26.70	26.71	26.78	27.26	26.77	26.76	26.76	27.27
Peridinians	2,800	3,100	1,650	520	4,650	4,180	1,930	440
Diatoms	1,100	810	220	40	2,040	3,430	1,200	2,330
(Dactyliosolen tenuis)	..	..	(20)	..	(1,900)	(3,100)	(740)	(160)
Coccolithophorides	2,000	800	800	400	5,060	5,080	3,590	1,000
(Pontosphaera huxleyi)	(2,000)	(800)	(800)	(400)	(1,200)	(1,600)	(400)	..
(Coccolithus pelagicus)	..	..	..	..	(3,600)	(3,200)	(2,950)	(960)
Flagellates	11,200	8,400	9,200	5,200	8,800	5,200	3,320	900
Infusorians	560	710	140	20	20	50	30	50

The plankton, which is not particularly rich is similar to that at St. 4659 (depth 1375 m.) in the Irminger Current, south of the submarine ridge (table 39). Unfortunately the determining of nutritive salts at all stations could not be carried out on that portion of the cruise. According to Böhnecke, Hentschel and Wattenberg (1930), however, the surface water here is rather poor in nutritive salts in August. The surface water is clearly stabilized at both stations, 4656 and 4659 (vide table 39). The plankton is poor compared with the quantity here in July 1932 though a distinct production can be traced. Coccolithophorides especially *Coccolithus pelagicus* and peridinians, most particularly small gymnodinians, dominated, of diatoms only *Dacty-*

Table 40.

Plankton per 100 ccm in the mixing area in the Denmark Strait, August 1933.

	St. 4660 65°37′ N 30°07′ W 9/8				St. 4664 65°04′ N 35°50′ W 10/8			
Depth in m	0	10	25	50	0	10	25	50
Temperature in ° C	4.90	5.03	9.60	7.42	4.77	5.01	4.53	3.87
Salinity, ‰	33.65	33.67	34.88	34.92	33.17	33.82	34.10	34.51
Peridinians	2,670	2,420	6,530	350	1,330	3,150	500	190
Diatoms	310	340	640	460	14,700	26,900	2,570	590
(Chaetoceros decipiens)	..	(100)	..	(40)	(3,560)	(1,440)	(490)	..
(Chaetoceros debilis)	..	..	..	..	(3,600)	(10,800)	(310)	..
(Nitzschia delicatissima)	(60)	(60)	(110)	(290)	(1,000)	(3,240)	(290)	(470)
Coccolithophorides	1,850	1,800	6,540	1,230	520	1,920	330	20
(Coccolithus pelagicus)	(680)	(620)	(4,740)	(1,090)	(120)	(1,600)	(330)	(20)
Flagellates	12,100	12,800	9,600	1,600	10,800	35,600	8,800	820
Infusorians	150	320	60	30	240	210	80	40

Table 41.

Plankton per 100 ccm in the East Greenland Stream, August 1933.

	St. 4667 63°38′ N 40°13′W 11/8			St. 4671 62°13′ N 42°04′W 12/8				St. 4682 60°00′ N 42°25′W 14/8			
Depth in m	0	25	50	0	10	25	50	0	10	25	50
Temperature in ° C	1.32	1.82	—0.15	2.96	2.47	1.06	0.78	2.20	2.14	0.63	—1.20
Salinity	29.51	31.69	32.66	27.52	28.17	30.70	31.94	31.36	32.39	32.79	33.12
Peridinians	250	150	30	100	30	90	80	200	180	50	50
Diatoms	1,020	840	2,450	..	..	..	80	..	190	..	..
(Chaetoceros decipiens)	(100)	(100)	(690)	..	..	..	(60)	..	..	..	..
Coccolithophorides	..	..	10	..	..	..	..	..	..	..	..
Flagellates	2,800	3,200	900	800	1,600	2,000	2,820	3,600	2,000	20	30
Infusorians	50	20	30	10	10	20	20	20	20	10	..

liosolen mediterraneus was found in anything like considerable numbers, but no small portion of the cells of this species were empty.

Stations 4660 and 4664 (table 40) lie in the mixing area between the Atlantic and the polar waters. While the plankton at St. 4660 is inconsiderable, the fairly large quantities of it at the more polar St. 4664 indicate a distinct production. Here it is the diatoms, particularly *Chaetoceros debilis*, that predominate. Further is to be mentioned the coccolithophoride *Coccolithus pelagicus*.

Stations 4667, 4671 and 4682 are taken in the East Greenland Current itself between 63°38′ N. and Cape Farewell (table 41). At these stations no determinations of the nutritive salts were made, but at Stations 4668, 4677 and 4683, which are situated in quite the same kind of water, this was done (table 42). Nitrates and phosphates in the surface layers of the East Greenland Current are entirely lacking in August. In conformity with the lack of nutritive salts, the plankton is poor particularly at the two southerly stations where practically no autotrophic species were found; at the most northerly station, 4667, a rather small quantity of diatoms was observed, though chiefly in the depths. The fairly small quantities of heterotrophic flaggellates are presumably a proof that some time has elapsed since the finish of the diatom maximum. Owing to the pronounced stratification in the East Greenland Current there is no possibility of any new production after the finish of the early summer maximum.

Table 42.

Content of the nutritive salts in the East Greenland Stream, August 1933.

	St. 4668 63°34′ N 40°00′W 11/8				St. 4677 60°47′ N 42°34′W 13/8				St. 4683 59°53′ N 42°50′W 14/8				
Depth in m	0	10	25	50	0	10	25	50	0	10	25	50	150
Temperature in ° C	4.93	4.90	3.12	—0.63	2.12	1.81	2.27	—0.39	2.90	1.16	0.15	—0.64	1.40
Salinity ‰	32.56	32.57	32.81	33.24	26.92	28.89	30.94	32.53	29.88	31.17	32.29	32.84	34.09
P_2O_5, mg/m³	0	0	0	10	0	0	0	15	0	5	10	20	35
N_{NO_3}, mg/m³	0	0	10	70	0	0	0	60	5	20	30	65	110

Table 43.

Plankton per 100 ccm in the mixing area at Cape Farewell, August 1933.

	St. 4680 60°39′ N 41°53′W 13/8				St. 4681 60°19′ N 42°11′W 14/8			
Depth in m	0	10	25	50	0	10	25	50
Temperature in ° C	8.23	8.07	8.05	8.02	3.91	4.15	5.60	6.51
Salinity	34.70	34.74	34.87	34.88	33.24	33.80	34.27	34.59
Peridinians	3,500	4,880	3,740	620	1,200	1,020	3,480	1,720
Diatoms	32,040	44,580	27,060	17,100	28,560	26,660	23,440	14,600
(Chaetoceros pelagicus)	(3,360)	(9,500)	(1,040)	(1,500)	(480)	(200)	(1,100)	(300)
(Chaetoceros debilis)	(15,260)	(18,500)	(6,380)	(5,800)	(24,200)	(20,900)	(11,800)	(5,400)
(Nitzschia delicatissima)	(800)	(8,000)	(11,600)	(2,000)	(740)	(2,400)	(4,400)	(3,600)
Coccolithophorides	560	580	820	220	420	820	480	980
Flagellates	6,800	8,000	10,260	2,400	4,500	9,200	8,800	6,500
Infusorians	120	60	20	40	180	60	20	..

Stations 4680 and 4681 (table 43) lie in the mixing area between the polar and the Atlantic waters at the south point of Greenland. Here we find a very vigorous plankton production; just as in the mixing area towards the north, it is the diatom *Chaetoceros debilis* that dominates. In addition there must be mentioned the diatoms *Chaetoceros pelagicus* and *Nitzschia delicatissima*.

St. 4685 and St. 4686 lie in the oceanic water east of Cape Farewell (table 44). According to Böhnecke (1931) this area must be designated as a subarctic mixing area, as the surface

Table 44.

Plankton per 100 ccm in the Irminger Sea, August 1933.

	St. 4685 59°47′ N 42°30′W 14/8			St. 4686 61°52′ N 35°30′W 15/8			
Depth in m	0	10	50	0	10	25	50
Temperature in ° C	9.34	9.14	7.00	10.97	10.91	9.57	7.20
Salinity	34.95	34.95	35.08	35.01	35.01	35.04	35.10
P_2O_5, mg/m³	15	20	45	..	..	..	..
N_{NO_3}, mg/m³	80	85	175	40	30	..	..
Peridinians	10,440	12,230	20	10,410	16,670	4,230	470
(Amphidinium sphenoides)	(2,400)	(3,200)	..	(2,000)	(3,200)	(30)	(10)
Diatoms	6,570	12,000	450	6,860	17,570	6,730	1,690
(Eucampia groenlandica)	(130)	(80)	..	(2,400)	(1,600)	(80)	..
(Fragilaria nana)	(1,200)	(2,400)	..	(1,200)	(3,600)	..	(30)
(Nitzschia delicatissima)	(3,200)	(7,600)	(400)	(3,600)	(9,200)	(6,000)	(1,600)
Coccolithophorides	4,000	2,840	410	22,040	17,210	3,300	1,630
(Pontosphaera huxleyi)	(1,600)	(2,000)	(400)	(10,400)	(9,600)	(1,200)	(800)
Flagellates	23,600	28,410	2,400	70,400	104,400	26,800	3,200
Infusorians	70	10	10	280	430	40	10

water is formed of Gulfstream water with an admixture partly of water from the East Greenland current and partly, perhaps, from the Labrador current as well. At St. 4685, which lies fairly close to Cape Farewell, a distinct admixture of water from the East Greenland current can be traced by the occurrance of neritic species like *Chaetoceros debilis* in small quantities. The salinity, which was 34.95 ‰, shows at the same time an admixture of water poorer in salt. At St. 4686, which lies out in the middle of the Irminger Sea, there can also be traced in the salinity, which was 35.01 ‰ in the surface waters, a distinct admixture; the neritic species observed here were, among others, *Cerataulina bergonii*.

In consonance with the results of the "Meteor" expedition in this area in August 1930, we now also find high values of nutritive salts in the surface layers. The plankton which is present in comparatively abundant quantities consists of a fairly equally proportioned mixture of coccolithophorides, peridinians and diatoms. The dominating species were the coccolithophoride *Pontosphaera huxleyi*, the diatoms *Fragilaria nana* and *Nitzschia delicatissima* and the peridinian *Amphidinium sphenoides* (table 60, appendix). Owing to very bad weather no investigations were undertaken on the rest of the trip towards Iceland.

Finally Stations 4695—4697 lie off the south coast of Iceland between Reykjanes and Portland (table 45). The hydrography and the phytoplankton are quite similar to what prevailed here two months earlier in 1932 and show that the production conditions here are, presumably, practically the same throughout the summer. The plankton conditions here in August 1932 were, according to Hentschel (1933) quite similar.

As at the end of June, there is now a distinct admixture of water, rich in nutritives, at the Vestman Islands (St. 4696), which brings about a very rich plankton production here. Taking them generally, the same species that were found here in June 1932 are found here now; it is only their mutual quantitative proportions that are different. Numerically the diatoms dominate, particularly *Thalassiosira nordenskjøldii*, *Sceletonema costatum* and *Nitzschia deli-*

Table 45.

Plankton per 100 ccm at the south coast of Iceland, August 1933.

	St. 4695 63°36′ N 21°31′W 24/8				St. 4696 63°25′ N 20°19′W 24/8				St. 4697 63°21′ N 19°10′W 26/8			
Depth in m	0	10	25	50	0	10	25	50	0	10	25	50
Temperature in ° C	11.77	11.54	9.88	8.58	9.38	9.34	9.28	8.97	10.92	10.80	10.90	9.9
Salinity, ‰	33.71	34.18	34.94	35.24	34.80	34.88	34.88	35.01	34.12	34.50	34.86	34.9
P_2O_5, mg/m³	0	0	15	60	30	30	40	40	..	..	..	..
N_{NO_3}, mg/m³	0	0	80	ca. 200	100	125	125	125	..	..	..	..
Peridinians	11,930	24,380	47,930	440	9,410	9,420	11,920	1,320	24,760	35,160	46,280	5,7
(Exuviaella baltica)	(4,400)	(12,000)	(25,000)	..	(7,200)	(4,800)	(8,400)	(400)	(21,200)	(17,600)	(17,200)	(7
Diatoms	730	2,230	1,830	130	51,690	42,740	44,290	27,140	8,510	9,620	7,260	7,7
(Sceletonema costatum)	..	..	(90)	..	(4,900)	(3,900)	(5,200)	(4,340)	(1,060)	(1,200)	(180)	(3
(Thalassiosira nordenskj.)	(90)	(80)	(60)	..	(17,600)	(12,000)	(12,800)	(6,000)	..	..	(50)	..
(Nitzschia delicatissima)	(400)	(840)	(1,200)	(100)	(8,000)	(9,600)	(8,000)	(6,000)	(3,200)	(4,800)	(4,000)	(4,0
Coccolithophorides	22,830	19,040	10,040	..	6,890	4,480	5,660	5,240	3,670	8,660	18,340	8,5
(Pontosphaera huxleyi)	(16,800)	(15,200)	(8,800)	..	(6,400)	(4,000)	(5,200)	(5,200)	(2,400)	(8,000)	(13,600)	(6,4
Flagellates	55,200	63,700	33,600	2,400	31,800	29,200	33,600	14,000	49,600	43,600	61,200	25,0
Infusorians	120	180	10	10	90	40	90	..	120	20	60	.

catissima. The peridinians which in June 1932 were very sparsely represented, are now found in fairly large quantities; the same applies to the coccolithophoride *Pontosphaera huxleyi*. Of the numerous naked flagellates no small number was autotrophic.

In contrast to the conditions in the immediate vicinity of the Vestman Islands, the surface waters at St. 4695 on the Selvogs bank and at St. 4697 at Portland were without any determinable quantities of nutritive salts. The relatively small quantity of diatoms is presumably the result of this. But there are many peridinians — particularly small gymnodinians and Exuviaella baltica. Coccolithophorides — especially Pontosphaera huxleyi — and small flagellates, of which the main bulk consisted of a Carteria species, were present in large quantities.

4. June cruise from North Iceland to East Greenland north of 70° N 1933.

In June 1933, Magister S. Lund during a cruise from the north coast of Iceland to Greenland, north of 70° N collected a number of surface samples (table 46 and chart 4, page 32.). The samples L 1 and L 2 were collected in the arctic water north of Iceland. The plankton which is very poor is analogous to what is found in the coastal water to the north of Iceland later in the summer. Only small flagellates, presumably heterotrophic species, are common. This points to a more vigorous production earlier in the year.

Table 46.

Plankton per 100 ccm on a section from Iceland to East Greenland north of 70° N, end of June 1932.

	Arctic water		Transition area	Polar water		
	St. L 1 67°00′ N 19°17′ W 23/6	St. L 2 67°56′ N 19°17′ W 23/6	St. L 3 68°43′ N 19°15′ W 24/6	St. L 4 69°35′ N 18°52′ W 24/6	St. L 5 70°11′ N 19°41′ W 24/6	St. L 6 70°23′ N 21°26′ W 25/6
Temperature in ° C	7.0	6.1	1.8	0.7	—1.6	—1.6
Peridinians	190	1,720	3,840	910	930	180
(Exuviaella baltica)	(60)	(1,600)	(1,600)	..	..	..
Diatoms	170	2,520	4,630	32,110	102,100	12,220
(Thalassiosira gravida)	(10)	(50)	(10)	(4,000)	(3,980)	(440)
(Chaetoceros furcellatus)	..	..	..	(10,000)	(7,600)	(2,400)
(Fragilaria oceanica)	..	..	..	(17,000)	(84,000)	(7,100)
(Nitzschia delicatissima)	(130)	(430)	(2,400)	(70)	(700)	(320)
Coccolithophorides	30	..	..	..	..	..
Flagellates	44,800	40,400	44,400	31,210	21,600	10,800
Infusorians	20	60	190	890	300	20

Sample L 3 lies in the transition area to the polar water (surface temperature 1.8° C.). Here also the quantity of plankton is fairly small. The samples L 4—L 6 were taken in the East Greenland Current, where the surface temperature at this time is negative. Now a very rich plankton is found among the ice floes where the producers consist almost exclusively of diatoms. *Fragilaria oceanica* and *Chaetoceros furcellatus* are the commonest species.

The nutritive salts were not determined; but it can be taken for granted that this is a spring maximum which, now that the ice has begun to melt and is spreading, has received the requisite conditions for production.

Chapter VI.

The limiting factors for plankton production.

Before we pass on to collecting the results regarding the plankton production in the various sea areas, we must deal with the factors that may be presumed to have a limiting effect on the production.

While just after the working out of methods to determine the nutritive salts, phosphates and nitrates, the planktonologists were inclined to the opinion that the quantity of these substances played the all-over-powering part as limiting factor for the plankton production (see for instance Hentschel and Wattenberg 1930), it has in recent years been discovered that the plankton production cannot everywhere be placed directly in relation to the quantities of phosphates and nitrates. Gran (1930) put forward the idea that the plankton production in the Weddel Sea in the antarctic could not get into swing until the surface was stabilized as otherwise the plankton algae would be carried away from the layer of water where the intensity of the light was sufficient for the effectiveness of assimilation. Hart (1934) in his excellent account of the plankton in the Antarctic Sea, explains very clearly the importance of stabilization for the plankton production there. Furthermore in mentioning the factors which in the East Cumberland Bay have a restricting effect on the plankton production, he advanced the idea that the very large quantities of inorganic detritus which are found deposited in the waters of that turbulent coast must be of great significance for the penetration of the light down into the sea and thus for the Co_2-assimilation of the plankton algae.

The available investigations from the seas around Iceland and the Faroes show that in our northerly waters too we must reckon with the instability of the surface waters and the content of detritus as factors of extraordinary significance for plankton production.

Broadly speaking there are only two factors that have a restricting effect on the production of phytoplankton in the northern waters; the light and the quantity of nutritive salts. But these two factors are again dependent on a lot of others which partially work into each other. A lot of other factors, as for instance temperature and salinity on the contrary, have as a rule only a regulating effect on the plankton production as, inter alia, they have an influence on the composition of the plankton and, as regards the temperature, at any rate also on the rapidity of the metabolic processes. It must, however, be admitted that the temperature in the northern waters may also have a restricting effect when it becomes so low that the water freezes. But as long as the water retains its liquid state, the temperature in the northern waters is never a limiting factor for the plankton as a whole while it may of course very well be so for certain species.

No sea area is, as far as we know, devoid of plankton because of the absence of spores to start production. Even in the most dead periods, some hibernating cells and spores have been found everywhere. But as regards the occurrence of any particular species, the absence of spores in a sea area where conditions favourable to such occurrence exist, will often be the limiting factor. Quite another problem is the question whether the number of hibernating cells is of significance as regards the point of time for the commencement of the production in the spring. Gran (1930) has advanced this opinion. In order to investigate this question more closely we must resort to a hypothetical case.

Let us suppose that there are two in all other respects similar masses of water A and B, but they contain 1 and 100 hibernating cells per 100 ccm, respectively (the number of hiber-

nating cells in the Northern Atlantic, for instance, is of this scale of magnitude). Then let us suppose that the conditions for production at a definite point of time suddenly increase from nought to optimum (e.g. the intervention of a stabilizing of the surface layers which, however, in nature does not of course occur instantaneously!) we shall then — provided we reckon that all the cells divide themselves twice in twentyfour hours — arrive at a number of 100,000 cells per 100 ccm (a rich plankton) in the course of $8^1/_2$ and 5 days respectively. The difference in the time for the occurrence of the spring maximum is only $3^1/_2$ days. The quantity of hibernating cells is of no great significance for the time of the occurrence of the spring maximum.

We have here reckoned with a rapidity of dividing at the rate of twice in the twentyfour hours. This is certainly not overestimated during the favourable conditions for production when the spring maximum in May sets in, in the Northern Atlantic and at the coasts of Iceland. Gaarder and Gran (1927) and Gran (1927 and 1933) have several times found such a rapidity of propagation of diatoms in seawater enclosed in glass bottles, submerged in the sea for three days. In other experiments carried out under similar circumstances the above named investigators found considerably less rapidity of propagation; but it must be taken into consideration that the conditions for plankton algae in such bottles are far from normal particularly when the sea is calm. If, on the contrary, the sea is somewhat rough, the buoy from which the bottles are suspended — and thereby also the bottles themselves — is exposed to jerks and shakings whereby the plankton algae are kept in suspension in the bottles. Steemann Nielsen (1932) has proved that the intensity of respiration and assimilation is considerably reduced, already by the second day, in such experiments (in this case the sea was calm).

Though, as stated, we must presumably reckon with a rapidity of propagation at the rate of at least two dividings in the twentyfour hours. Under the same circumstances as stated above but if every cell divided itself only once a day the difference would, howevers, be less than a week; nor in that case would the number of hibernating cells be of essential importance with regard to the time for the occurrence of the spring maximum.

The quantity of phytoplankton does not always give a perfectly reliable picture of the size of the production itself. The quantity eaten up by the animals — a factor which unfortunately is nearly terra incognita — will, to be sure, often effect an apparently greater paucity of phytoplankton than strictly speaking, considering the amount of the production, one would suppose (cpr. Harvey 1934). The usually very low values of phytoplankton at the north coast of Iceland during the summer are perhaps due, in no small part, to the very intense grazing of the huge swarms of *Calanus finmarchicus* which are so often found here, at that season of the year.

1. The light.

That the light during the winter months is not sufficiently strong for an effective CO_2-assimilation, even in the uppermost layer of water, so far north as the areas under discussion, may be taken for granted. Gran (1930) and earlier investigations show, however, that the plankton production on the west coast of Norway as far north, at any rate, as Lotoften (ca. 68° N.) is in full swing in the middle of April and at Möre (ca. 63° N.) already at the end of March. At this time the light in the surface layers of the seas around Iceland (ca. 62° -66° N.) must consequently be sufficient for the assimilating activities of the plankton algae. The investigations in 1934 show, however, that the plankton production in the area in question does not begin until some time in May. Factors which on the coast of Norway may be without significance must be the reason for the plankton production beginning so late on the open ocean and off the coasts of Iceland and the Faroe Isles.

Of such factors must be mentioned the instability of the surface water and the content of detritus; the latter, most likely, is of importance only in coastal areas, while the first, above all, makes itself felt on the open sea, though at a long series of coast stations the reason for the late florescence may also be ascribed to this factor (cpr. Braarud and Klem 1931). A third factor must be added to the two already mentioned, and that is the depth, which in some cases can neutralize the effect of the instability of the surface water. The sum-total of the effects of these three factors will, as a rule, in the northerly waters, determine the occurrence of the spring maximum after the sunlight has been strong enough on the whole for a fairly extensive CO_2-assimilation.

The effect of the instability of the surface water must, as both Gran (1931) and Hart (1934) mention, be understood thus that the plankton algae are carried away from the uppermost layer of water where the light is sufficient for the CO_2-assimilation. When the water masses lack stability, stormy weather has the effect of causing a vigorous stirring in the open waters. But if there is a difference in the specific gravity of the surface water as compared to that of the deep lying layers on account either of the higher temperature or lower salinity no considerable exchange will take place between the surface and the deeper layers of water and the plankton algae will consequently not be carried away from the surface and the light. As soon as the surface water in the open sea is stabilized the plankton production can, as a rule, begin. On the other hand, in a sheltered fjord, production may very well be able to begin before the occurrence of the stabilization, as the stirring of the volumns of water here will never be particularly vigorous. This was the case in Rödefjord in May 1934 (cpr. Braarud and Klem 1931, page 70).

Off the coast of Norway the surface water is stabilized throughout the winter, owing to the poor salinity of the Baltic Current which flows in the surface along the coast. The winter convection, owing to the very great difference in the salinity between the surface and the deeper layers, will effect a mixing only in the uppermost layers.

On account of the warming of the upper layers, the surface water out in the open ocean will also be stabilized. The discontinuity layer, in the latitudes with which we are dealing, generally lies at a depth of about 25 m (vide table 56, appendix). The winter convection will here, as the stabilization is only contingent upon the difference in temperature, effect a perfect mixing of the surface water with the deeper layers. In the northern part of the Atlantic the winter convection reaches down to a depth of about 500 m (vide St. 5082 table 3, page 9).

In the part of the Atlantic above referred to the plankton production will not begin until, on account of the summer warming, the surface water has been stabilized. In 1934 this had not yet occurred in the first half of May. The weather conditions will be of great importance in determining when the stabilization will occur and thereby also when the plankton production will begin.

Off the coasts of Iceland the mixing during the winter is very effective. At most of the stations, in May, there was found to be an even distribution of temperature and salinity from the bottom to the surface (table 4, page 11). In the open Faksefjord, in the middle of May 1934, the surface water was partially stabilized (table 4, page 11). Owing to the immense quantities of inorganic detritus in the water the production conditions here were somewhat different, as will be explained later on.

Where particular circumstances do not intervene the stabilization in the area here dealt with will always, sooner or later come about. Some exceptions, however, exist. On the southern slope of the submarine ridge between Iceland and Greenland any pronounced stabilization

of the surface water will seldom take place and this stabilization will not even be constant as the mixing, presumably, will take place spasmodically with special wind or tidal-water conditions. If during the mixing processes the vertical movements extend deep downwards there will be no good conditions for plankton production while the mixing processes are in progress. The plankton algae will not have the repose for their CO_2-assimilation activity which on account of the light can take place only in the surface layers. But if the mixing processes cease for some time, a vigorous production will set in, as the nutritive salts will now be present in the surface water in abundance and the algae will not be carried away from the surface.

Along the southern slope of the submarine ridge between the Faroes and Iceland the surface water is generally rather instable in the summer (vide table 27, page 26). This can only to a slight extent be ascribed to the effect of the mixing processes between the Atlantic and the Arctic water. The chief reason must be sought in the formation of eddies which accompany the upwelling of the more deeply lying layers, which takes place on the southern slope of the submarine ridge (cpr. fig. 1, page 54). Also on the south side of the submarine ridge between Iceland and Greenland such an upwelling of deeper lying water takes place, and the lack of stability in the surface layers in the mixing area between the Irminger Current and the East Greenland Current is, most probably, due to a certain extent to the eddies caused by this upwelling. By the sides of the Shetland-Channel there are also areas, according to JACOBSEN and JENSEN (1926), with powerful vertical movements. The forming of eddies which accompanies the upwelling of deeper lying volumes of water along the sides of the channel will here also be the cause of the disturbance in the surface water. In the following chapter the hydrographic conditions in the areas here mentioned will be more fully discussed.

Though comparatively large quantities of plankton are generally found in these areas, exceedingly large amounts are as a rule, never found. This is especially the case over the ridge between the Faroes and Iceland.

The formings of eddies in connection with the upwelling of deep water are presumably subject to fluctuations owing to differences in the tidal conditions and perhaps also to the various wind conditions. In any case the volumes of water must occasionally be partially in repose so that conditions for plankton production may exist. Our knowledge of this subject is, however, still exceedingly slight.

At the coasts of the Faroe Isles a very vigorous vertical mixing is found all the year round. This is due to the very strong tidal currents here which at the many points and between the islands bring about the formation of powerful eddies. The hydrography at the Faroes will be more specifically treated on page 59.

Nevertheless the plankton production at the Faroes is rather considerable throughout the whole summer. Off the coasts of Iceland, on the contrary, there is as a rule only a very small production in the tide races which are usual off some of the several projecting points, as for instance, Staalbjerghuk, though here, just as at the Faroes, nutritive salts are steadily conveyed up to the surface layers. To solve this problem we must discuss the other two factors which, together with the vertical circulations, are of importance to enable the plankton algae to utilize the light viz. the depth and the transparency of the water.

If the transparency of the water is great, the plankton algae can assimilate CO_2 at much greater depths than where it is slight. On the cruise in May 1934, a Pulfrich photometer[1]) was

[1]) The Pulfrich photometer on the "Dana" was similar to the model used by KALLE (1931) for the colourmetering of phosphates in sea-water. Eight different glass filters were used whereby the absorption of light could be measured from 430 to 740 mμ.

used to measure the transparency, the spectral absorbtion of light in a 25 cm column of sea water being compared with the corresponding absorbtions in a column of distilled water. As water in itself absorbs the red portion of the spectrum very vigorously, it is only the blue and particularly the green rays which can penetrate down to any great depths.

In table 47 there is, for a number of selected stations on the April—May cruise in 1934, given the co-efficient of extinction for the light of the following wave lengths:— ca. 490 mμ

Table 47.

The extinction of light in water in the different areas, May 1934.

Area	Station	Locality	$\varepsilon \cdot 10^3$, 490 mμ (blue)	$\varepsilon \cdot 10^3$, 530 mμ (green)	Length in m of a column of water, which reduces parallel green light (530 mμ) to 1 per cent.
West coast, Iceland	5092	Fakse bay	9.6	8.0	2.5
— —	5098	Snefellsnes, inner st.	4.1	3.0	6.7
— —	5100	— outer st.	2,4	1,7	11.8
Southwest coast, Iceland	5086	Selvogsbank, inner st.	5.0	3.6	5.6
— —	5088	— outer st.	2.1	1.4	14.3
Southeast coast, Iceland.....	5109	Vestrahorn, I, inner st.	5.8	4.7	4.3
— —	5110	— II	4.1	2.8	7.1
— —	5111	— III	2.4	1.7	11.8
— —	5112	— IV, outer st.	1.6	1.0	20.0
Northeast coast, Iceland.....	5134	Langanes, inner st.	5.0	3.7	5.4
— —	5135	— outer st.	2.5	1.9	10.5
The Norwegian Sea	5140	.....	1.7	1.1	18.2
Faroe Isles.....	5149	Fuglö, inner st.	2.3	1.5	13.3
—	5148	— II	1.7	1.0	20.0
—	5147	— III, outer st.	1.5	1.0	20.0
—	5033	Skaalefjord	3.8	2.6	7.2
Faroe bank	5079	.....	2.2	1.5	13.3
North Atlantic	5082	.....	2.0	1.2	16.7

and ca. 530 mμ. The co-efficient of extenction is calculated as the sum of the co-efficient of extinction of distilled water plus the co-efficient of extinction of sea water in relation to distilled water.

The co-efficient of extinction ε is calculated in accordance with the equation $\frac{J}{J_0} = 10^{-\varepsilon . x}$ where x is the thickness of the layer in cm. The values for distilled water are taken according to Lange and Schusterius (1932) in which work $\varepsilon \cdot 10^3$ of fresh redistilled water is 1.3 by 490 mμ and 0.8 by 530 mμ. According to these authors ε of ordinary distilled water that has stood in a laboratory is somewhat larger.

Though on the "Dana" ordinary distilled water was used, the statements for the fresh redistilled water were, however, employed for the blue and the green rays, as the difference between redistilled and distilled water, in this case, is not particularly pronounced. The values for the extinction of the red rays are on the other hand entirely rejected as the difference in their case was far too large.

On the basis of the co-efficient of extinction is calculated the length of a column of water which reduces parallel green light (530 mμ) to 1 %. By this means we get a relative measure to determine how far the light can penetrate down into the sea in the various areas. At what depth the green light is in reality 1 % of the light in the surface layer is of course impossible to determine on this basis as the rays of light in nature are not usually parallel nor do they fall vertically on the surface of the sea; furthermore the quantity of light in the Pullfrich photometer is reduced not alone owing to direct absorption but also to diffusion; as, however, several of these factors act in an opposite direction, in nature the depth to which 1 % of the light in the surface water reaches downward is, presumably, of somewhat the same order of magnitude as the length of the column of water which reduces parallel rays of light to 1 %. Furthermore this depth corresponds, presumably, to some extent to the compensation-point for the daily metabolism of the plankton algae in the summer, in these latitudes[1]). The values in the table are, however, used only for the comparison of the transparency at the various stations. In determining the co-efficient of extinction only the values for the surface water have been used though the absorption was also measured in water from 10, 25 and 50 m depths. The divergences between these depths mutually were scarcely ever of much importance as the measurements were carried out before stabilization had occurred.

On the open ocean the absorption of light is slight. Inorganic detritus which is derived from land can be carried out here to a very small extent. Nor will the absorption of light contingent upon the plankton organisms play any part now, in May, as the production is not in progress. It is only when the water has a depth of about 18 meters that the green light is reduced to 1 %.

Off the coasts of the Faroes the absorption of light is also slight, generally not greater than on the open sea. An exception is the stations in the fjords where there is a continual supply of matter from the land.

Off the coasts of Iceland on the contrary, the absorption of light in May is very great almost everywhere. This must be contingent upon the large quantities of matter conveyed from the land in conjunction with the rough weather whereby the detritus is held in suspension in the water. One finds consequently an inverse relation between the absorption of light and the distance from the coast. Particularly high values for the absorption of light were found especially in the Fakse Bay. At St. 5092 a column of water of 2.5 m was, for instance, sufficient to reduce the quantity of green light to 1 %. In the shallow bay the matter deposited at the bottom will constantly be eddied up during the rough winter and springtime.

The reason for the great transparency of the coastal water at the Faroes is that the sea bed here generally is hard i.e. there is no deposit of matter that can be brought up. The bottom along the coasts of Iceland is, on the contrary, generally covered with fine vulcanic sand which, when the sea is rough is easily eddied up. The constant supply of matter from land must also be greater at Iceland owing to the vulcanic activity there. Furthermore a very strong sanddrift often occurs on the south coast of Iceland. The very fine sand may be carried far out to sea. It is for a very great part owing to the inferior transparency of the water at the coasts of Iceland in the spring that the plankton production here does not begin till very late. That is, at any rate, as far as Fakse Bay is concerned, where the surface water owing to the difference

[1]) Investigations at Iceland in May-June 1935 where at the same time measurements of light and determinations regarding the metabolism of the plankton were made, have confirmed this. A publication dealing with this will later on be issued.

of the salinity was partially stabilized, the chief reason why the plankton production in the middle of May 1934 was not in full swing.

Unfortunately it was not until the spring cruise in 1934 that investigations regarding the transparency of the water were made. In the summer, however, the transparency of the water at the coasts of Iceland must be considerably greater than during the winter and spring. CO_2-assimilation experiments which were made in the Fakse Bay in June 1932 show that the plankton algae assimilate down to about 15—20 m and that the compensation point for the daily assimilation and respiration lies at a depth of between 10 and 15 m (table 48) which must correspond to a fairly high transparency of the water.

Table 48.

The intensity of the CO_2-assimilation in mg O_2/l of surface-water exposed for twentyfour hours at various depths in Fakse Bay at St. 4421a (64°00′ N 22°32′ W) $^1/_7$—$^2/_7$ 1932. The intensity of respiration was at the same time 0.16 mg O_2/l. The sky was slightly overcast.

Depth in m	Intensity of CO_2 assimilation in mg O_2/l
0.5	0.52
1.0	0.52
2.0	0.48
5.0	0.46
10.0	0.26
15.0	0.02

As soon as the calm weather dominates, the detritus in suspension will sink to the bottom and the pronounced stratification, which during summer prevails, now makes it very difficult for precipitated matter at the bottom to return to the surface layers.

Large quantities of plankton will, of course, also effect a perceptible reduction of the transparency of the water. It would be of the utmost importance to have investigations made regarding the transparency of the water at different seasons of the year in the various sea areas.[1])

From table 47, p. 46, it appears that the transparency of the water in the spring in the fjords at the Faroe Islands was considerably less than in the open coastal water. This must certainly also be the case in summer. Investigations in June 1932 show, however, that the transparency of the water in such a fjord (Vaagfjord) was comparatively great. Measures were taken to determine CO_2-assimilation and respiration of surface water with the natural content of plankton exposed at various depths for twentyfour hours. Four series of experiments were made (June 15th to June 20th). The light conditions were the same during all the experiments as the sky was practically speaking, never overcast. The point of compensation for the daily assimilation and respiration lay, in all the experiments, somewhat below 10 m; the maximum assimilation for twentyfour hours went down to a depth of ca. 5 m. The experiments show that the transparency of the water in the Faroe fjords during summer is comparatively great. Out in the open coastal waters a considerably greater transparency must, however, be reckoned with at that time of the year.

As the transparency of the water at the coast of the Faroes is good and at the same time the depth is generally not much over 100 m, the effect of the vertical movements of the waters will, at any rate partially, be nullified. Though the plankton algae have to accompany the waters on their vertical journey a rather considerable production can, nevertheless, occur as the layers in which the algae can assimilate are fairly considerable in proportion to the layers of water as a whole. Exceedingly large quantities of plankton are, however, never found at the coasts of the Faroes, as the vertical movements despite everything, have a restraining influence

[1]) As a result of more recent investigations by the author in 1935 it was found that during a vigorous phytoplankton production in the beginning of June off Skagi $\varepsilon \cdot 10^3$ for green light was about 1.5. Even when there are large quantities of phytoplankton present in the sea, the values for the extinction of light do not reach nearly so high as those attained in the winter and spring.

on the production. The total annual phytoplankton production is on the contrary large as owing to the constant supply of nutritive salts (cpr. page 60), it continues without interruption throughout the summer.

While at the Faroes a considerable plankton production occurs throughout the summer, though the water masses are in a constant state of vertical movement, the production during summer in the powerful tide-races off several of the projecting points at Iceland is very small; this must be due to the inferior transparency of the water there. Matter from the bottom (as already stated there is much deposit off the coast of Iceland!) will throughout the summer be eddied up and owing to the strong vertical currents be carried up to the surface. Therefore, though there are nutritive salts in the surface waters of the tide races at Iceland just as there are at the Faroe Isles throughout the summer, there will nevertheless not be a possibility for any real production owing to the inferior transparency of the water.

It has already been mentioned that the fact that the depth of water is inconsiderable can partially counteract the effect of a lack of stability in the volumes of water. We have a very typical example of this in the isolated Faroe bank south west of the Faroe Islands. Though the volumes of water were not stabilized here when the "Dana" visited this area in the beginning of May 1934 (vide table 3, page 9) the production of phytoplankton was, however, beginning (vide table 2, page 9). Whereas out on the ocean, where the volumes of water were not stabilized either, the production, practically speaking, had not begun at all. The reason for the production beginning earlier over the bank must certainly be ascribed to the water not being very deep there. Even though a constant vertical circulation of the volumes of water and the algae must be reckoned with, the layers of water where the light is adequate to the CO_2-assimilation of the algae, are sufficiently large in relation to the entire volumes of water to effect production. The transparency of the water was approximately the same over the bank and out on the ocean (vide table 47, page 46).

The length of the day is particularly of great importance for the production of phytoplankton in a coastal area with lacking stability of the surface waterlayers. As the plankton algae here are on a constant wandering between the euphotic and the oligophotic waterlayers the real day for the plankton algae is but short. As it is necessary for the propagating of the algae that the proportion between the time of the stay of the algae in light and darkness at least has a certain minimum value, a prolongation of the day will get the possibility for the propagating of the algae to rise. In the instabilized waters at the Faroes the production first begins during May. At the same latitude on the coast of Norway, where the surface water is stabilized in early spring this happens according to Gran (1930) already at the end of March. The prolongation of the day in these northern latitudes during that time is ca. 50 %.

At the same time the intensity of light also increases whereby the light, when the transparency of the water is the same, can go farther down. This effects a greater extent of the euphotic waterlayers. The proportion between the time for the stay of the algae in the euphotic waterlayers and the time for the stay in the oligophotic waterlayers at the Faroes has increased hereby in an extraordinary degree and has so during May reached such a great value that an effective production of phytoplankton takes place. In an area with vertical mixing the real length of the day for the plankton algae first late in the spring reaches the minimum value for an effective production. Further the real length of the day very early in the autumn again will come below minimum. The season for the production of phytoplankton in such an area does not last very long.

A special factor for production of phytoplankton in the East Greenland Current is the ice. First when this melts the light in the watermasses will become sufficient for an effective CO_2-assimilation.

2. The nutritive salts.

In the foregoing section it has been shown how complicated the light conditions actually are for the plankton algae. Many different factors interfere with one another. The vertical movements of the water proved to be of particular importance. We shall now see, as already mentioned in the said section, that these vertical movements are in other ways important for the plankton production, as richly nutritive water is hereby conveyed to the surface. NATHANSOHN (1906) was the first to call attention to the importance of the vertical currents for the conveyance of the nutritive salts to the surface.

In the spring before the production is well in progress, there will everywhere in the areas here dealt with, be large quantities of nitrates and phosphates present in the surface layers, generally about 30—50 mg P_2O_5/m^3 and about 100—150 mg N_{NO_3}/m^3. Where no further amounts of phosphates and nitrates are conveyed to the surface water the production will, about a month after its start, have culminated, the nutritive salts will have been consumed in about the uppermost 25 m, and a quantitatively poor plankton will now be found. This is what happens in the Atlantic south of Iceland and in the East Greenland Current and partly at the west and north coasts of Iceland.

Where there, on the contrary, is a constant admixture of richly nutritive deep-water throughout the summer, there will, where other factors do not intervene — such as for instance vigorous vertical mixing in conjunction with inferior transparence of the water — be conditions for a large plankton production throughout the summer.

In the section on light, mention has already been made of the most important areas where vertical movements take place regularly in the summer. The Vestman Island area, off the south coast of Iceland, must be mentioned as another important place where richly nutritive deep water is carried to the surface throughout the summer and thus creates the possibility for a continuous, vigorous plankton production. In the following chapter the hydrographic conditions in the various areas will be more closely dealt with. The nutritive conditions will, of course, be discussed thoroughly.

Not only on the spot itself where the richly nutritive deep water comes up to the surface, but also in the neighbouring areas there is often a basis for a vigorous plankton production as the water may be carried by the surface currents over large areas. We have a typical example of this in the Irminger Sea. Though, as a rule, no vertical mixing takes place in the Irminger Sea itself during the summer, the production of plankton, nevertheless, is generally vigorous here as a steady supply of richly nutritive surface water is carried here from the mixing areas along East Greenland. The areas in the vicinity of the places where the vertical movements occur have very often even a richer plankton production than the mixing areas themselves, as the production here in some other way is restrained by the vertical movements of the water. The content of nutritive salts is, on the contrary, always largest where the vertical movements actually occur. Besides the areas where the surface receives a constant supply of richly nutritive water from the depths, there are others where such an admixture can sometimes take place. Close in under the north coast of Iceland we sometimes find upwelling of bottom water (cpr. page 68). This upwelling is very variable and of a purely local character; it is, presumably, brought about only by quite special wind and current conditions (vide St. 4468, table 22, page 22). Such places create conditions for small local plankton maxima.

Chapter VII.

The annual plankton production in the various areas.

Already when going through the records of the different cruises a partial division of the area was made use of. We shall now collect the hydrographic and planktonological data from the various areas in order to attain to an understanding of the progress of the annual plankton production in these areas.

The following division will be employed:

1. The Gulfstream area in the northerly part of the Atlantic over fairly great depths.
2. The Faroe-Shetland Channel.
3. The Gulfstream area over the submarine ridge between the Faroes and Iceland.
4. The Irminger Sea.
5. The East Greenland Current.
6. The mixing area in the Denmark Strait and along the coast of East Greenland.
7. The coastal area at the Faroes and the Faroe-bank.
8. The coastal area at Iceland.
   a. The south coast.
   b. The west coast.
   c. The north coast.
   d. The east coast.
   e. The Icelandic fjords.
9. The central "Arctic" portion of the Norwegian Sea.

1. The Gulf Stream area in the northernmost part of the Atlantic over fairly great depths.

Ostenfeld (1898, 1899 and 1900) made investigations regarding phytoplankton in this area at all seasons of the year. Paulsen (1904 and 1909) also treated the plankton from this place, but none of the collections resulting from these and various other investigations in this area were quantitative. They were made with the aid of silk bags, with which catching nanoplankton organisms is quite out of the question, and as the plankton in the open sea consists almost exclusively of these organisms, these investigations are quite inadequate for the purpose of elucidating the actual conditions of production. We must therefore have recourse entirely to the investigations carried out on the "Dana" cruises in 1932—1934 besides to some data from the "Michael Sars" Expedition 1924, Gran (1929).

Throughout the winter and the beginning of spring the plankton production is quite minimal. The effect of the vertical currents owing to the winter convection is that the CO_2-assimilation activity of the plankton algae cannot begin even far in the spring, though the light in the surface layers is strong (vide page 44). By the winter convection the nutritive salts have, however, come up to the surface and as soon as the water here has been stabilized owing to the summer warmth there will therefore be a possibility for a very vigorous plankton production. The discontinuity layer is generally found at a depth of about 25 m.

The weather conditions naturally play a very great part as regards the time the stabilization takes place; it generally occurs during May. When the "Dana" visited the area at the

beginning of May 1934, it had not yet occurred and consequently the spring maximum of the plankton had not begun either (vide table 2 and table 3, page 9).

But when, at the end of June 1932, the "Dana" visited the area (vide table 12, page 15) a very rich plankton was found here, consisting principally of the coccolithophorides (*Pontosphaera huxleyi* and *Syracosphaera dentata*. The main part of the nutritive had been consumed in the uppermost 25 m above the discontinuity layer. The remainder will probably soon be used up and a plankton minimum will take the place of that rich spring maximum that has existed since about the middle of May. Gran (1929) showed that the plankton was very poor in the North Atlantic in late summer.

In the course of the summer there is generally no possibility whatever of a supply of richly nutritive water to the surface out over the deep ocean. Not until the stabilization in the surface layers was done away with by the winter refrigeration will richly nutritive water be again carried up to the surface; this will not, however, bring about a plankton production till next May.

2. The Faroe-Shetland Channel.

The main volume of the Gulf Stream water which flows into the Norwegian Sea comes — according to Helland-Hansen and Nansen (1909) — through the ca. 1000 m deep Faroe-Shetland Channel. Jacobsen and Jensen (1926) have given us an idea of the fairly complicated hydrographic condition that exist in this channel. On the sides of the channel along the 600 m isobath there is in summer a vertical mixing which, according to Jacobsen and Jensen is the result of the formation of eddies in the strong current along the edge of the shelf (vide fig. 25, Jacobsen and Jensen 1926). The deep water which on the slopes at the sides of the channel is pressed upwards contributes, no doubt, to the formation of the eddies.

A quantitative plankton investigation in the Faroe-Shetland Channel was at an earlier date instituted by Miss Ogilwie in connection with Gran's investigations regarding the spring plankton production in the North European waters (Gran 1915). The investigations were made in May—June 1913. Unfortunately the samples of water used for the centrifugation were preserved in ancidiferous fluid owing to which the coccolithophorides, the quantitatively predominating organisms in those waters, were destroyed. These investigations, therefore, give an erroneous impression of the phytoplankton beyond the coastal banks.

When at the end of April 1934 the "Dana" crossed over the Faroe-Shetland Channel, the plankton was very poor (vide table 2, page 9). The production, just as in the northerly Atlantic, had not yet begun as the surface waters were not yet stabilized. The nutritive salts were present at the surface in the same quantities as out in the open ocean (ca. 35 mg P_2O_5 and 100 mg N_{NO_3} per m^3).

The production begins, most likely, somewhat about the same time as out over the ocean i.e. during May. When the "Dana" about the 1st of June, 1934, was again crossing over the Faroe-Shetland Channel, there was, unfortunately, no plankton collected there. The chemical investigations, however, showed that the plankton production must at that time have begun. In comparison to the oxygen percentages below 100 at the close of April there was a distinct supersaturation with oxygen which could not alone be ascribed to the warming up of the surface water to about 1° C.; the absolute quantities of oxygen had increased as well, though only in a slight degree (table 49).

In the middle of June 1932 the plankton production was in full swing in the Faroe-Shetland Channel. The plankton corresponded exactly to that found in the open ocean at that

Table 49.

The absolute quantities of oxygen in ccm/l and the percentages of saturation at the end of April and about the 1st of June 1934 in the Faroe-Shetland channel.

Depth in m	61°28′ N 3°42′W				61°08′ N 2°10′W			
	St. 5023 $^{23}/_{4}$		St. 5180 $^{31}/_{5}$		St. 5021 $^{21}/_{4}$		St. 5182 $^{1}/_{6}$	
	O_2	O_2%	O_2	O_2%	O_2	O_2%	O_2	O_2%
0	6.28	96	6.62	104	6.37	98	6.55	103
10	.27	96	.78	106	.35	98	.55	102
25	.26	96	.66	103	.35	98	.50	101
50	.29	96	.43	99	.32	97	.12	95

Table 50.

The quantities of phosphate (mg P_2O_5/m^3) at the surface in the Faroe-Shetland channel outside the coastal banks, July-August.

Date	Stat.	Position	P_2O_5 mg/m³
$^{12}/_{7}$ 1934	5290	61°40′ N 4°40′W	10
$^{12}/_{7}$ 1934	5291	61°32′ N 4°02′W	10
$^{12}/_{7}$ 1934	5292	61°21′ N 3°10′W	10
$^{13}/_{7}$ 1934	5294	61°01′ N 1°36′W	20
$^{24}/_{7}$ 1933	4572	60°17′ N 5°31′W	10
$^{8}/_{8}$ 1932	4507	61°14′ N 4°40′W	25
$^{8}/_{8}$ 1932	4508	60°35′ N 3°46′W	25

time. The coccolithophoride *Pontosphaera huxleyi* was the dominating species (table 12, page 15).

Here reference is made only to the plankton in the middle of the Channel over fairly deep water. Further in on the shallow banks as for instance at the Faroes the hydrographic conditions are quite different. Accordingly the plankton conditions are also different (vide page 59).

Throughout the summer there is a considerable plankton production in the Faroe-Shetland Channel. This is due to the constant supply to the surface of richly nutritive water from the depths along the slope of the shelf along the 600 m-isobath. To the west at the inlet port for the Atlantic water this supply to the surface is certainly greatest. Owing to the complicated current conditions which Jacobsen and Jensen (1926) have described, the richly nutritive surface water must to a great extent be carried over the entire area. Therefore, though the surface water is stabilized over the greater part of the Faroe-Shetland Channel throughout the summer, nutritive salts will generally be found in the surface water everywhere though in varying quantities (table 50).

In proportion to the quantity of the nutritive salts a vigorous plankton production generally occurs in the channel throughout the summer at least in the southwestern part. The plankton is oceanic. The coccolithophorides *Pontosphaera huxleyi* and *Syracosphaera dentata* dominate. Besides these must be mentioned the little diatom *Fragilaria nana*. St. 4508 from August 1932 (table 57, appendix) gives a clear idea of the plankton in the summer. Closer investigations regarding the extent of the area in the Faroe-Shetland Channel where the production is rich, would be very interesting.

3. The Gulf Stream area over the submarine ridge between the Faroes and Iceland.

In this area a constant supply of richly nutritive water from the depths to the surface occurs throughout the summer. This, without doubt, is due to the fact that the Gulf Stream water flowing in from the south, on the slope of the ridge at about the 600—500 m-isobaths, is pressed upwards towards the surface. The fig. 1 shows distinctly how the deeper layers of water along the south slope of the ridge are pressed upwards towards the surface. And here

the stability in the surface layers is but slight (table 27, page 26) which must be due to the formation of eddies which, presumably, as a rule accompany such an upwelling of deep water. Section no. II, pl. XXI, by KNUDSEN (1899) corresponds somewhat to fig. 1; here a distinct upwelling on the slope of the submarine ridge between the Faroes and Iceland is also to be seen. Furthermore SEIWELL (1931) found, that during summer here nutritive salts were carried to the surface.

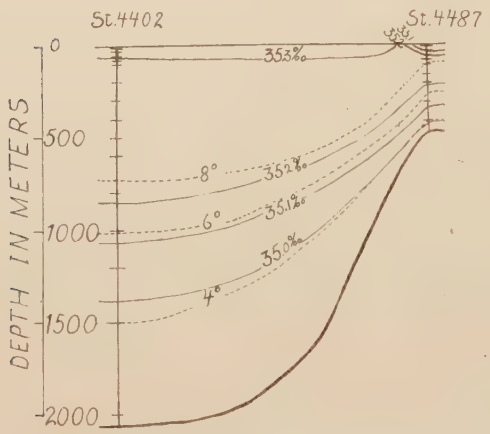

Fig. 1. A section showing how the Atlantic deep water is pressed upwards at the south slope of the submarine ridge between Iceland and the Faroes. Compare Chart III, page 16.

The distinct though slight admixture of arctic water in the surface layers at St. 4487 where the salinity was 35.07 ‰ (vide table 27, page 26), is, presumably, also a result of the formation of eddies.

Owing to the constant supply of richly nutritive water to the surface, a comparatively large plankton production will be found throughout the summer, though owing to the partly instable conditions in the surface waters it will never be exceedingly vigorous (vide table 27, page 26, and table 33, page 33). It is very misleading when BUCH (1934) places this area and the Faroe-Shetland Channel in contrast to "das isländische Assimilationsgebiet" north of Iceland, where the plankton production in the summer is very slight. The large quantities of carbonic acid in the surface water during the summer in the former areas are absolutely not due to an inferior CO_2-assimilation activity but on the contrary to a constant admixture of deep water, rich in carbonic acid, with the surface water. The composition of the phytoplankton is just like that in the Faroe-Shetland Channel. Coccolithophorides dominate, especially *Pontosphaera huxleyi*, but the little diatom *Fragilaria nana* is also found here.

4. The Irminger Sea.

Unfortunately the "Meteor" expedition's large hydrographic material from this area has not yet been published in its entirety. BÖHNECKE, HENTSCHEL and WATTENBERG (1930), BÖHNECKE, FÖYN and WATTENBERG (1932) and BÖHNECKE (1931) have given synopses of the hydrographic and biological conditions of the surface water (as regards the more important features of the hydrography vide page 5).

According to BÖHNECKE, HENTSCHEL and WATTENBERG the transition between the Atlantic and the polar waters is formed by stationary eddies which are said to be particularly distinct towards the north, in the Denmark Strait. The 500 m isobaths go through these eddy-areas. Richly nutritive deep water is in these areas carried up to the surface. The above mentioned authors explain the conveyance of water from the depths here as a dynamic result of the raising of deeper lying water in the centre of stationary eddies which have a cyclonic rotatory direction. This explanation sounds very theoretical. That the formation of eddies takes place and nutritious water is conveyed from the depths in the transition area between the Atlantic water and the Polar water of the East Greenland Current are facts that cannot be doubted. The hydrographic material from the "Dana" expeditions also confirms this. But that the water from the depths is conveyed to the surface owing to upheaval in the centres of the stationary eddies is, on the contrary, rather problematic.

Over the submarine ridge between the Faroes and Iceland, a similar conveyance of nutritious water from the depths to the surface exists (vide page 54). The formation of eddies also exists here but the rotatory direction of these eddies is generally anticyclonic (cpr. Helland-Hansen and Nansen 1909, fig. 39). According to Böhnecke, Hentschel and Wattenberg absolutely no upwelling of water from the depths should occur here. As, however, such an upwelling does occur here and in exactly the same way as over the submarine ridge between Iceland and Greenland, it is only reasonable to conclude that the phenomenon at both places is due to some other cause than that stated by the above mentioned authors. Partly the deep water is pressed up along the submarine slopes (cpr. Thomsen 1934, fig. 8, sect. III), partly the eddies, no matter in which direction they rotate, must be considered to effect a mixing both horizontally and vertically.

The water conveyed to the surface from the depths in the mixing area between the Atlantic water and the polar water of the East Greenland Current is exclusively of Atlantic origin. It is only in the volumes of water of the Atlantic that upwellings of the deep lying layers are found, and besides the surface layers in the East Greenland Current, owing to an inferior salinity as compared with the somewhat deeper layers, are so firmly stabilized that it would be impossible for any considerable exchange of volumes of water, in a vertical direction, to take place here.

As far as can be concluded from the profiles regarding the distribution of nitrates and phosphates in Böhnecke, Foyn and Wattenberg (1932), fig. 2, the conveyance of the nutritious deep water to the surface is greatest towards the south, in the vicinity of Cape Farewell.

No investigations to determine the time when stabilizing and the beginning of the plankton production dependent on it, takes place in the Irminger Sea are available. Very likely it occurs a deal later than in the Gulf Stream water south of Iceland, presumably not until June. While at the end of June 1932 the surface temperature in the Gulf Stream south of Iceland was over 11° C and the difference between the surface temperature and that at a depth of 50 m 2.5° C, the surface temperature everywhere in the Irminger Stream in the middle of July 1932, was still below 10° C and the difference between the surface and 50 m about 1.0° C. This shows that the warming up of the surface water in the Irminger Sea proceeds more slowly than in the sea to the south of Iceland, and as stabilization is principally dependent on the warming up of the surface, a more tardy process in this respect means a later occurrence of the stabilization.

From the statements of frequency in the lists of plankton published by Paulsen (1904) it will be seen that in the middle of June 1903 a rich plankton was found in the Irminger Sea to the west of Iceland. The production must certainly have only just begun as the surface water was stabilized only to a small extent (vide Bulletin trimesteriel for 1903).

On the cruise of the "Dana" in the Irminger Sea in the middle of July 1932 a very rich plankton was found (vide table 32, page 31). The diatoms *Nitzschia delicatissima* and *Fragilaria nana*, in particular, were present in large quantities. The nutritive salts were found in fairly large quantities.

The water in the Irminger Current is, for the most part, Gulf Stream water which comes from the sea to the south of Iceland. But everywhere in the Irminger Current the salinity in the surface water is somewhat lower than in the pure Gulf Stream water, which, doubtless, is due to a slight admixture of water from the mixing areas along the coast of East Greenland. Towards the east the salinity at the surface is generally lowest. The less saline water can be carried out over the whole of the Irminger Sea as the current here runs partly in circles.

The considerable quantities of nutritive salts that are brought up to the surface along

the coast of East Greenland and in the Denmark Strait are therefore distributed over a large part of the Irminger Sea. In the area between Cape Farewell and the Reykjanes ridge large quantities of nitrates and phosphates are found in the surface waters throughout the summer. In August, therefore, there is a pronounced difference in the content of nutritive salts between the more Gulf Stream-affected area towards the northeast in comparison with the area with a more "subarctic" mixture of water towards the southwest. As a circulation must, however, as already stated take place in the Irminger Sea, nutritive salts will to some extent be carried from the southwest area to the northeast area.

According to Böhnecke (1931) possibly a supply of nutritious water from the depths to the surface occurs also by the passage of the Gulf Stream over the Reykjanes ridge. This is very likely correct. The deep water along the south slope of the Reykjanes ridge is forced upward which, at any rate occasionally, under special wind or tide water conditions may be able to bring about the formation of eddies and the consequent vertical mixing, though the depth is about 1000 m. Both in August 1929 and 1930 the "Meteor" expedition found particularly large quantities of plankton here.

If we compare the results accruing from the three years quantitative investigations which were made in the Irminger Sea during August ("Meteor" in 1929 and 1930, "Dana" in 1932) we find a distinct difference in the plankton production in August between the south westerly, nutritious, "subarctic" part of the area and the more Gulf Stream affected northeasterly part where the nutritive salts were found only in small quantities. In August the production in the area towards the southwest with the subarctic mixed water, is still vigorous, which is compatible with the large quantities of nitrate and phosphate here. According to Böhnecke, Føyn and Wattenberg (1932) coccolithophorides dominated here in August 1930. The same was the case in August 1933 when the "Dana" visited this area (vide table 44, page 39). As many as 20,000 coccolithophorides per 100 ccm were found, particularly *Pontosphaera huxleyi*, *Syracosphaera sp.* and *Coccolithus pelagicus*. Peridinians and diatoms, especially *Nitzschia delicatissima*, were however, also found in fairly large quantities, besides a great deal of naked flagellates.

In the more Atlantic-affected area, towards the northeast the production in August is a great deal smaller than in the area towards the southwest (vide table 39, page 37). About 5000 coccolithophorides, about 5000 peridinians and about 2000 diatoms were found per 100 ccm. In August 1929, according to Böhnecke, Hentschel and Wattenberg, the plankton in that part of the area consisted chiefly of peridinians. If we compare the quantities of plankton in August with what was found here in July 1932, we notice a distinct falling off. This is due to the fact that the diatoms which in July were found in exceedingly large quantities have now almost disappeared.

In the branch which the Irminger Current sends up into the Norwegian Sea over the submarine ridge in the Denmark Strait, the plankton in August 1933 corresponded very

Table 51.

The hydrography at the Sts. Øst 37 (17.8.1929, 25°35′ W 66°25′ N) and "Dana" 4656 (8.8.1933, 25°33′ W, 65°40′ N) showing the stabilisation of the surface layers.

Øst 37				Dana 4656			
Depth in m	t in °C	S ‰	σ_t	Depth in m	t in °C	S ‰	σ_t
1	11.07	35.16	26.90	0	11.50	35.00	26.70
10	.01	.16	.91	10	.48	.00	.71
25	10.72	.16	.99	25	.09	.00	.78
40	.02	.16	27.09	50	7.81	.11	27.26
75	7.93	.16	. 43	100	6.97	.15	.56
170	6.89	.16	.57	225	.64	.16	.61

well to that in the Irminger Current south of the Denmark Strait (vide table 39 page 37). The surface water was firmly stabilized (St. 4656). The same was the case when the "Ost" Expedition's St. 37 (Braarud & Rudd 1932), which lies in the same branch of the Irminger Current, was taken in 1929 (table 51). In the branch referred to above, where it passes over the submarine ridge in the Denmark Strait, no vertical movement, presumably, takes place so late in the year to enable the nutritive salts to come up into the surface layers. The movement in that volume of water is certainly, as a rule, slight, and this is evident from the fact that generally only a faint trace of the Atlantic water is found north of Iceland (vide Helland-Hansen and Nansen 1909).

When the plankton production in the Irminger Sea proper ceases, cannot be said with certainty as no quantitative plankton investigations have ever been made here later than August. The frequency reports in the plankton tables from the Angmasalik route (Wandel, Ostenfeld and Knudsen 1900) indicate, however, that in the subarctic mixed water to the east of Greenland, a quantitatively rich plankton was found in the beginning of September 1899. Several of the diatoms are shown as having a frequency of CC, but one must be careful in using that kind of specification in respect of production investigations. However, everything indicates that the plankton production in the southwestern part of the Irminger Sea does not cease until either the light becomes too weak or the winter convection sets in and causes an intensive mixing whereby the plankton algae are carried away from the surface. In the northwestern part, on the other hand, the production after the middle of August generally is not considerable.

Though the plankton production begins very late in the Irminger Sea, the annual production must be very large particularly in the subarctic mixed water in the southwesterly part of that area.

5. The East Greenland Current.

As soon as the ice begins to melt in the East Greenland Current the plankton production sets in, as the water from the melted ice causes a very firm stabilization of the surface layers. No doubt the production begins earliest to the south of the Denmark Strait but, as a rule, it is sure to have begun over the greater part of the area at the end of June. Even as high up towards the north as 70° N. this was the case in 1933 (vide page 41).

It can be safely reckoned that at the surface, before the production commenced there was a content of about 35 mg P_2O_5 and about 70 mg N_{NO_3}[1]). While the nutritive salts in the middle of July 1932 had not yet been consumed at the two easterly stations in the polar current, in the Denmark Strait, and the plankton production was therefore still in full swing, the nutritive salts at the westerly stations were, on the other hand, practically speaking consumed, and the production had culminated as the plankton was about to sink (vide table 30, page 28).

The plankton everywhere in the East Greenland Current during the early summer maximum consists principally of diatoms. Otherwise it is only the naked flagellates that are most in evidence. Thus in some places we find very large quantities of the autotrophic species *Phaeocystis pouchetii*. Of the diatoms we must particularly mention *Chaetoceros furcellatus*, *Fragilaria oceanica*, *Thalassiosira gravida* and *Thalassiosira nordenskjöldii* (vide table 2, appendix).

[1]) Look for instance at the contents of nutritive salts at a depth of 50 m at St. 4432, table 30, p. 28. These quantities correspond probably to the quantity in the surface just before the beginning of the phytoplankton production as the winter refrigeration must cause an intensive mixing of the whole of the polar layer of the East Greenland current.

After the rich early summer maximum has disappeared a very poor time for the plankton in the East Greenland Current follows. The nutritive salts are quite consumed and, owing to the very firm stabilization of the surface, no nutritious water whatever can be conveyed up to it from the depths. On the cruise in August 1933, nitrates and phosphates could not be shown at the stations, in pure polar water along the coast of East Greenland (table 42, page 38). Correlative with this was the extreme poorness of plankton, for instance, at St. 4671 (table 41, page 38) where only 910 organisms per 100 ccm were found in the surface water, and of these, 800 were small heterotrophic flagellates.

The relatively great values of the nutritive salts in August in the surface waters of the East Greenland Current, as reported by the "Meteor" expedition in 1929 and 1930, are rather incomprehensible. In table 1 of Böhnecke, Føyn and Wattenberg 1932 the average quantity of N_{NO_3} is stated to be 25 mg/m³, $P_{P_2O_5}$, 5 mg/m³. In calculating the average values, single stations with a small mixture of water from the adjacent nutritious mixing area have perhaps been included.

In the East Greenland Current after a fairly short, vigorous florescence of the plankton in the early summer, practically no plankton production takes place during the rest of the season. The East Greenland Current must therefore be described as a poor area in respect of production.

Ostenfeld and Paulsen (1909—11) give valuable information regarding the qualitative composition of the microplankton in the East Greenland Current.[1])

6. The mixing area in the Denmark Strait and along the coast of East Greenland.

When discussing the Irminger Sea the vertical mixing processes in the transition area between the Irminger Stream and the East Greenland Current were mentioned and we shall therefore here deal only with the actual production conditions for the plankton in this area.

Owing to the steady supply of nutritious Atlantic deep water to the surface a vigorous plankton production is found in this area throughout the summer, though the quantity of both the nutritive salts and the plankton may of course vary very much from place to place. Throughout the summer the plankton consists of a mixture of species from the polar East Greenland Current and the Atlantic Irminger Stream (vide table 31a, 31b, 40 and 43. The polar element is represented chiefly by the diatoms *Chaetoceros furcellatus*, *Chaetoceros debilis* and *Thalassiosira gravida*, besides occasionally of the flagellate *Phaeocystis pouchetii*, while the most numerous representatives of the Atlantic element are the diatoms *Nitzschia delicatissima* and *Fragilaria nana* and a smaller number of various coccolithophorides. The proportion between the Atlantic and the Polar water as it appears from the temperature and salinity corresponds generally to the proportion between the two respective plankton groups as well. The numbers of the plankton in the mixing area never reach so high a figure as in the Irminger Current when the production is at its highest there, which is due, most likely, to rather unsettled hydrographic conditions in the mixing area. Sudden changes in the salinity caused by the mixing processes may also be considered to have an injurious effect on many plankton algae, as these are sensitive to sudden changes in the osmotic state. The changes of temperature during the mixing are certainly of less importance although their significance for the plankton production cannot be ignored. In the late summer on the contrary a uniformly larger plankton production will, as a rule, be found in the mixing areas as compared with the Irminger Current. This is evident

[1]) While in press a valuable paper concerning the production of phytoplankton in this area has been published, Braarud 1935.

both from the results of the "Meteor" expedition in August 1930 (Böhnecke, Foyn and Wattenberg (1931) and those of the "Dana" expedition in 1933.

As shown in the section on the Irminger Sea the large quantities of nutritives at the surface in the southwesterly part of that sea must be due mainly to the admixture of nutritious water from the mixing area along the coast of East Greenland. The transition is therefore, from a biological point of view, very equable between these two areas. What has been said regarding the duration of the season for the plankton production in the southwesterly part of the Irminger Sea must therefore also be taken to apply to the mixing area proper.

7. The Coastal area at the Faroe Isles and Faroe-bank.

The very strong tidal current at the coasts of the Faroes with the formation of strong eddies in many places (vide Den Færoske Lods 1917) causes a constant mixing of the volumes of water. The temperature and salinity are practically always uniform from the bottom to the surface in the coastal water at the Faroes. The velocity of the tidal currents varies greatly, as just after new or full-moon when the moon has been nearest the earth, the current is about 3 or 4 times as strong as immediately after the changes of the lunear quarters, when the moon has been furthest from the earth. The formation of eddies and the consequent vertical mixing varies therefore in a high degree, but no real stabilization ever occurs at the coasts of the Faroes.

The volumes of water at the Faroes must be fairly stationary though a rather small supply of new water is constantly occurring. This is indicated, inter alia, by the plankton which in the coastal water around the isles generally consists of other species than in the adjacent oceanic waters. The supply of new water which occurs to the coastal area at the Faroes must consist partly of water from the deeper layers; this doubtless is a consequence of an upwelling of Atlantic deep water along the slopes out towards the Atlantic, in conjunction with the formation of eddies here. This is indicated by the low temperature in the coastal waters at the Faroes as compared with that in the oceanic waters around, and only in that way can one explain the invariably fairly high values of the nutritive salts throughout the summer, though a fairly vigorous plankton production continues to occur (vide table 52) consuming the nutrient compounds.

Table 52.

P_2O_5 and N_{NO_3} in the surface water at the Faroe Isles. 4th of May 1934 off Troldhoved, 25th of May off Fuglö, otherwise off Myling.

	P_2O_5, mg/m³	N_{NO_3}, mg/m³
$^4/_5$ 1934	35	100
$^{25}/_5$ 1934	25	ca. 90
$^{23}/_6$ 1932	50	50
$^{27}/_7$ 1933	35	70
$^{31}/_7$ 1932	30	85
$^{28}/_8$ 1933	40	ca. 100

The conditions are assuredly similar to those on the Faroe-bank south west of the Faroes, where according to Knudsen (1911) along the slopes out towards the fairly deep water, layers of water are carried up from the depths on to the bank.

Seiwell (1931) understands the renewal of water at the Faroes in quite another manner, for he assumes that no exchange with the surrounding bodies of water can take place at the Faroes in the summer as the water over the bank has become lighter owing to the great heating. The temperature in the coastal water at the Faroes during the summer is, however, as already mentioned, lower than that in the surrounding bodies of Atlantic water! Seiwell relies partly on Nansen (1913) page 26 who disagrees with Knudsen (1911) in his conception of the exchange of water on banks in the ocean, partly on the low values of phosphates in the surface water

at two stations at the Faroes in July 1928. If these estimates of the phosphates are correct the samples must either not have been taken in the actual coastal water or quite exceptional conditions must have prevailed here. In 1932—1934 where at all times of the summer a large number of determinations regarding the nutritive salts were made at the coasts of the Faroes, these salts were always present everywhere on the banks in practically invariably rather large quantities (vide table 52, and for a large number of other stations the material published in Bulletin hydrografique). It is just these large constant quantities of the nutritive salts that are taken as a positive proof that during summer a steady supply of water from the depths occurs at the Faroes.

The plankton production at the coasts of the Faroes begins in May as may be seen from the investigations in 1934. While the samples taken early in May contained only slight traces of phytoplankton, those taken at the end of that month showed that the production had started (vide table 1, page 8, and table 10, page 14). At the end of May, 1913, Poulsen (1918) found a fairly large quantity of plankton here.

The phytoplankton production, therefore, begins here somewhat about the same time as out over the open ocean. There are, however, quite different causes for the late beginning in the two places. While the establishing of a stabilized surface layer is the reason why production can begin out on the open ocean, the coastal water at the Faroes is never stabilized owing to the strong tidal currents with their forming of eddies. The plankton algae will therefore always be exposed to great vertical movements here with the effect that the plankton will be fairly evenly distributed from the bottom to the surface (vide table 28, page 27, and table 64, appendix). Already Gran (1929), page 5, draws attention to this. The plankton algae will therefore alternately be up in the surface layers where the light is sufficient for the process of assimilation and down in layers where the light is too weak.

Owing to the small quantities of deposited inorganic detritus at the Faroes (vide page 47) the light penetrates comparatively far down and permits of the algae assimilating at fairly considerable depths. The compensation point for the daily assimilation and respiration lies, presumably, at about the depth of 30 m during the summer. Though the algae are, therefore, exposed to violent vertical movements on the coastal banks at the Faroes, where the average depth is about 100 m, they will receive light for a sufficiently long time during the twentyfour hours for production to occur as soon as the days become sufficiently long and that is what happens in May. From the end of March till the middle of May the length of the day at the Faroes increases about 50 % (cpr. page 49).

It is to be supposed, that the production of phytoplankton only continues as long as the long days prevail at the Faroes. In the autumn no production of importance probably takes place. Quantitative plankton investigations have, however, not been made here in this season.

Though the production is distinct during the whole summer, one never finds even approximately such enormous quantities of plankton as during the spring maximum in a coastal area, where the surface water is stabilized, as for instance at the south coast of Iceland; this is due to the restricting influence of the vertical movements. The phytoplankton production of the whole season is only moderate.

During the whole of the production season it is the diatoms that dominate. At the end of May 1934 those most in evidence were *Sceletonema costatum*, *Thalassiosira* species, *Chaetoceros furcellatus* and *Nitzschia seriata* (vide table 10, page 14); in June 1932, *Rhizosolenia faeröense*, *Nitzschia delicatissima* and *Leptocylindrus* species predominated (vide table 64,

Table 53.

The hydrography and chemestry in Vaagfjord, 61°27′.8 N 6°45′ W (St. 4382: 61°28′.2 N 6°47′.2 W) 1932—1934, arranged in accordance with the advancing seasons.

Station	Date	Depth in m	t in ° C	S ‰	σ_t	$100 \frac{O_2}{O_2'}$	P_2O_5, mg/m³	N_{NO_3}, mg/m³
5065	2/5 1934	0	6.69	35.16	27.60	..	..	..
—	—	10	.69	.16	.60	..	..	..
—	—	25	.69	.16	.60	..	..	..
—	—	40	.69	.14	.59	..	..	..
5163	28/5 1934	0	7.40	35.19	27.53	..	..	..
—	—	10	.34	.21	.56	..	..	..
—	—	40	.32	.21	.56	..	..	..
4382	21/6 1932	0	11.32	35.29	26.95	..	20	0
—	—	5	.19	.28	.97	..	20	0
—	—	10	8.88	.28	27.37	..	15	15
4577	25/7 1933	0	10.43	35.23	27.05	..	10	35
—	—	10	.30	.25	.10	..	15	40
—	—	20	.18	.25	.12	..	20	60
—	—	40	9.80	.25	.19	..	40	70
4505	7/8 1932	0	9.88	35.20	27.15	98.3	30	70
—	—	10	.80	.19	.15	99.5	35	85
—	—	25	.77	.19	.15	99.5	40	90
—	—	40	.73	.20	.17	99.7	..	70
4711	1/9 1933	0	10.67	35.10	26.93	..	5	80
—	—	10	.69	.14	.96	..	5	80
—	—	25	.57	.20	27.03	..	10	90
—	..	40	.53	.20	.03	..	15	90

appendix) and finally at the end of July 1932 the most noticeable were *Chaetoceros contortus*, *Chaetoceros debilis* and *Nitzschia delicatissima* (vide table 28, page 27). The peridinians and coccolithophorides are always of little or no importance.

The conditions for the plankton production in most of the fjords are very much the same as in the coastal water. Jacobsen (1915) and Kiilerich (1928) have thoroughly worked out the hydrography of the Faroe fjords. Owing to the strong tidal currents, a vigorous exchange of water exists in all the fjords. This has the effect that even here the surface water is not generally stabilized, at any rate for any length of time. Only in the fjords where there is a typical threshold at the entrance, the hydrographic conditions are somewhat different.

The plankton production was investigated in the two fjords, Vaagfjord and Skaalefjord. The former is a typically open fjord without any threshold. At the beginning of May 1934 the production was at the very earliest stage of its commencement (St. 5065, table 1, page 9). There was no stabilization whatever (table 53).

At the end of the month the production inside the fjord, like that outside of it, was in full swing (St. 5163, table 10, page 14). The surface water was not even now stabilized (table 53).

In June 1932, determinations of plankton and nutritive salts were made only at St. 4382, which lies in shallow water in the inner part of the fjord (table 13, page 15). Here there was found a fairly rich plankton consisting of diatoms, particularly *Chaetoceros* and *Thalassiosira* species. The nutritive salts were partially consumed (table 53).

In the beginning of August 1932 a rich diatom plankton was still found in Vaagfjord;

Table 54.

The hydrography and the amounts of nutritive salts in Skaalefjord (62°07′ N 6°44′ W) 1932—1934, arranged in accordance with the advancing seasons.

Station	Date	Depth in m	t in ° C	S ‰	σ_t	P_2O_5, mg/m³	N_{NO_3}, mg/m³
5033	$^{24}/_{4}$ 1934	0	6.06	34.87	27.46	35	80
—	—	20	.00	.99	.56	35	80
—	—	25	.13	35.03	.57	35	90
—	—	50	.26	.12	.63	40	90
5174	$^{31}/_{5}$ 1934	0	7.79	34.85	27.20	..	..
—	—	10	.17	.97	.39	..	..
—	—	50	.14	35.10	.50	..	..
4392	$^{22}/_{6}$ 1932	0	10.03	35.13	27.06	..	..
—	—	10	8.93	.18	.29	..	..
—	—	25	7.86	.22	.49	..	..
—	—	50	6.73	.17	.61	..	..
5259	$^{5}/_{7}$ 1934	0	10.74	34.90	26.76	0	0
—	—	10	8.89	35.01	27.16	30	80
—	—	50	7.33	.08	.45	100	100
4585	$^{26}/_{7}$ 1933	0	11.31	35.14	26.84	0	0
—	—	10	10.41	.22	27.07	20	50
—	—	25	9.19	.22	.28	50	60
—	—	50	7.21	.16	.52	100	>100
4495	$^{2}/_{8}$ 1932	0	10.01	34.96	26.93	15	0
—	—	10	9.76	35.04	27.04	20	0
—	—	25	.01	.16	.25	70	90
—	—	50	7.46	.13	.45	>80	100
4701	$^{29}/_{8}$ 1933	0	11.38	34.49	26.32	0	0
—	—	10	10.97	.87	.69	20	60
—	—	25	.39	35.14	27.01	45	100
—	—	50	7.89	.16	.42	ca. 120	ca. 250

it consisted of very nearly the same species as in June (St. 4505, table 28, page 27). Oxygen, temperature, salinity and nutritive salts were evenly distributed from the bottom to the surface (table 53). A vigorous exchange of water must just have taken place in the fjord.

The conditions were the same in 1933 when on the 25th July (St. 4577) a slight stabilization was found with somewhat larger quantities of nutritive salts in the depths and on the 1st September (St. 4711), where also quite a slight stabilization was shown to exist in connection with a slight decrease of phosphates in the surface water (table 53).

In contrast to Vaagfjord, Skaalefjord is a typical threshold fjord. Here the plankton production had, already at the end of April 1934, begun (St. 5033, table 1, page 8). The surface water was just about to become stabilized (table 54) and supersaturation in oxygen was found both at the surface and at a depth of 10 m (table 55a). The nutritive salts were present in large quantities at all depths though a fairly small consumption had taken place in the surface water (table 54).

During the summer the surface water is always firmly stabilized in the Skaalefjord. In table 54 are given the hydrographical and chemical data at St. Skaalefjord III (62°07′ N 6°44′ W) at the times "Dana" was there in 1932—1934. The exchange of water in the Skaale-

fjord must generally be slight as only a very small quantity of nutritive salts appears in the surface water later in the summer. From a depth of 10 m and downward there are on the contrary always large quantities of nitrates and phosphates. Sometimes the plankton production therefore, ceases, presumably for lack of nutritive salts. This was presumably the case in June 1932, when the plankton was very poor (St. 4392, table 13, page 15). Unfortunately determinations regarding nitrates and phosphates at that particular time are not available.

Sometimes, however, fresh nutritious water must be conveyed to the surface from without. The rich plankton which at the beginning of August 1932 was found at St. Skaalefjord III (St. 4495, table 28, page 27) was probably due to such a supply of nutritive salts from without. Phosphates were still found in the surface layers in fairly large quantities.

It is, however, only the surface water in the Skaalefjord which in the summer has anything like a regular exchange with the water outside the fjord. The water in the depths must, on the contrary, be very stationary at that season. This is indicated, inter alia, by the very high values of the nutritive salts late in the summer; this is particularly noticeable as regards the phosphates (table 54). During the winter the waters in the depths of Skaalefjord are renewed principally on account of the winter convection. In the spring (St. 5033) the values of the nutritive salts in the depths at Skaalefjord correspond, therefore, exactly to the values which otherwise are found everywhere at the Faroes. But during the summer a gradual increase of these salts takes place in the depths of the fjord. This must be due to their liberation from plankton that has sunk. As the surface water occasionally receives supplies of nitrates and phosphates from without and the plankton production is therefore continued throughout the summer, with of course intervals of very little production, it is no inconsiderable quantity of plankton which during that season sinks down to the depths. The very large quantities of nutritive salts found here during the summer is therefore to be understood, as is likewise their distinct increase as the season advances.

Kiilerich (1928) is of the opinion that the renewal of water in the Skaalefjord is most probably slight occasionally, though most often just as vigorous as in the fjords without thresholds. This doesn't agree with the aforementioned investigations of the distribution of nutritive salts. Moreover table 55a shows that during the summer a steady decrease in the oxygen percentages generally takes place in the depths of Skaalefjord within the threshold. This also indicates that the waters in the depths of the fjord are stationary at that time of the year. In 1927, however, the water was entirely renewed in the depths at the end of June (vide table 55b) which even as late as the end of August that year could be distinctly noticed.

Table 55 a.

The percentages of oxygen in Skaalefjord (62°07′ N 6°44′W) 1924—1934, arranged in accordance with the advancing seasons. The values for 1927 are to be found in Table 55b.

Depth in m	$^{24}/_{4}$ 1934	$^{20}/_{5}$ 1925	$^{26}/_{5}$ 1926	$^{22}/_{6}$ 1932	$^{26}/_{7}$ 1933	$^{2}/_{8}$ 1924	$^{2}/_{8}$ 1932	$^{18}/_{8}$ 1925	$^{29}/_{8}$ 1933
0	102	111	..	122	122	130	118	129	114
10	102	107	101	112	102	..	118	119	102
25	99	100	93	97	89	89	89	104	89
50	98	96	98	61	64	56	56	65	50
55—68	99	94	94	60	54	53	46	60	44

Table 55 b.

The percentages of oxygen in Skaalefjord (62°07′ N 6°44′W) 1927.

Depth in m	$^{29}/_{6}$	$^{22}/_{8}$
10	107	..
25	106	93
50	..	75
55—68	103	71

The hydrographic conditions in the rest of the fjords on the Faroe Isles will generally correspond to the conditions in Vaagfjord. So we must therefore expect to find a vigorous plankton production everywhere here throughout the summer.

In connection with the conditions for the phytoplankton production at the Faroe Isles a brief account must be given of the isolated Faroe-bank which lies southwest of the Faroes themselves. The hydrographic conditions correspond, on broad lines, quite to those prevailing at the Faroes (vide KNUDSEN 1911 and JACOBSEN 1915). The oceanic element in the plankton is, however, larger on the Faroe bank, which must be due to its more isolated situation in the ocean.

When the "Dana" visited the bank at the beginning of May 1934 a uniformly oceanic plankton was found there (table 2, page 9), the production had only just commenced. The oceanic diatoms *Nitzschia delicatissima* and *Fragilaria nana* together with the coccolithophoride *Pontosphaera huxleyi* dominated; of the neritic species *Chaetoceros debilis* must especially be mentioned.

As the production in the ocean beyond the bank had not begun at all (vide table 2, page 9) and the surface water was nowhere stabilized, the earlier commencement of the plankton production over the bank was due to the lesser depth there as compared with the ocean beyond (cpr. page 49). The transparency of the water over the Faroe bank was good (vide tabel 47, page 46).

The same state of things has been the cause of the fairly large quantities of plankton which PAULSEN in May 1910 (PAULSEN 1911) and in May 1913 (PAULSEN 1918) found on the Faroe-bank as compared to the sea beyond. So early in the season the quantities of nutritives in the surface water are, owing to the winter convection, the same on the bank and on the open ocean. The supply of water from the depths along the declivities of the bank can therefore hardly be regarded as the reason for the fairly large production over the bank in May as PAULSEN (1911 and 1918) assumes. But when PAULSEN in September 1904 (vide PAULSEN 1909 and 1911) found a rich plankton on the Faroe-bank, it probably was due to the constant supply of nutritious deepwater along the declivities of the bank.

8. The Coastal area at Iceland.

Along the coasts of Iceland, as at the Faroes, there is found a plankton which differs very distinctly from the plankton out at sea. The coastal waters on the banks along the coasts of Iceland generally form a relatively independent water area which is only slowly renewed by supplies from without. The hydrographic conditions and thereby also those for the plankton production are, however, very unlike on the various stretches of the coast so it will be necessary to deal with these separately.

a. The South Coast of Iceland.

According to "Den islandske Lods" the current is rather irregular here. Neither is the tidal current strong nor regular and it only becomes of importance where it encounters opposition as for instance by the Vestman Islands. A quantity of fresh water flows out into the sea along the south coast of Iceland, causing a perceptible reduction of salinity here.

According to the sections from the Ingolf expedition (KNUDSEN 1899) the water from the depths is pressed up along the slopes of the banks on the south coast of Iceland. On the banks

themselves, however, no considerable admixture of nutritious deep water to the surface takes place in the summer, as the strong tidal currents in conjunction with the formation of eddies, as they occur at the Faroes, do not generally exist here. The surface water is, therefore, firmly stabilized during that season.

Throughout this time of the year it is only just around the Vestman Islands, where the shelf is quite narrow, that a regular supply of nutritive salts to the surface takes place. This is due to the mentioned upwelling of water in conjunction with the comparatively strong tidal currents in the immediate vicinity of the Vestman Islands (see St. 4403, table 14, page 17).

Sometimes a supply of nutritious deep water to the surface here, where the shelf is quite narrow, may, according to NIELSEN (1904, page 19) also occur, when the light coastal water, owing to strong northwesterly winds, has been driven to sea. It is possible that further west, at the slopes of the banks off Reykjanes, water from the depths is also, at times, carried right up to the surface. The large quantity of nutritive salts at St. 4413, table 15, page 18, is very likely to be interpreted in this way.

The winter refrigeration occasions a thorough mixing of the volumes of water on the south coast of Iceland. When, therefore, the light in the spring becomes sufficient for the carbonic acid assimilation of the plankton algae, the water is not stabilized. The weather, especially the state of the wind, in the spring must be of very great significance as regards the time the production will begin. On the banks at Iceland this cannot occur as long as the surface layers are not stabilized and the water consequently is too intransparent (vide page 47). Only quite near the land in very shallow water, does production begin before stabilization generally has been established. On the cruise of the "Dana" in May 1934 it was likewise found that the production started first quite close in, at the coast (vide table 7, page 12).

As a supplement to the present investigations the plankton tables of OSTENFELD (1898—1900) and PAULSEN (1904) are very useful. Though these investigations were not quantitative the frequency records, however, show distinctly when the actual production sets in.

At the beginning of the spring maximum the content of nutritive salts is about 35 mg P_2O_5 and 100 mg N_{NO_3}. It is therefore a very vigorous plankton production that is found at the south coast of Iceland in the early summer, when the stabilization is an established fact. The amount of inorganic detritus in the water must at this time be considerably less than in the spring, for owing to the calmer weather so much sand is not blown off the land nor is so much of the deposit at the bottom of the sea whirled up. Besides the stabilization now has the effect that the substances that have once sunk below the discontinuity layer are only with great difficulty carried up again to the surface. The result of this is that the transparency of the water is most likely better now than during the spring, even though the large quantities of plankton must, of course, affect the absorption of light[1]).

As already mentioned, nutritive salts are throughout the summer supplied to the surface water around the Vestman Islands. Here, therefore, there is a possibility for a very vigorous plankton production during the whole of the summer (vide table 14, page 17, and table 45, page 40). But in other places as well, on the banks off the south coast of Iceland — at any rate west of Portland — a fairly large quantity of plankton is found at this time of the year (vide table 15, page 18, and table 45, page 40), though, generally, no nutritive salts can be shown in the surface waters at these places. The plankton production must, however, depend on the nutritious water carried up to the surface around the Vestman Islands perhaps in conjunction with further supplies of deep water to the surface further west, along the slopes. Also among

[1]) Investigations in May-June 1935 have shown the correctness of this (vide also page 47).

the many rocks and skerries outside Reykjanes, the tidal currents and surf must, at any rate occasionally, be able to cause vertical movements of the waters.

Hentschel (1933) found a rich plankton in August 1932 off the south coast of Iceland to the west of Portland and is also of the opinion that this must be due to a supply of nutritious water from the depths. According to Hentschel (1933) table 2, page 266, the plankton production during late summer is rather small on the southcoast to the east of Portland. The "Dana" did not make any investigation here at that time of the year.

The diatoms almost always dominate in the plankton off the south coast of Iceland. When the first production begins it is the species *Sceletonema costatum*, *Thalassiosira gravida* and *Thalassiosira nordenskjöldii* that dominate. Later on, when the really vigorous production sets in, the most prevalent species are *Chaetoceros cinctus*, *Asterionella japonica* and *Leptocylindricus minimus*. The coccolithophoride *Pontosphaera huxleyi* and several peridinians, such as *Exuviaella baltica* can, occasionally, also be found in large quantities (vide tables 14, 15, 45 and tables 65, 66, appendix).

b. The West Coast of Iceland.

The conditions for plankton production at the west coast of Iceland are rather different to those at the south coast. On the west coast the deep water is not pressed up along the slopes of the banks (cpr. Thomsen 1934, fig. 8, sect. IV). This is probably the reason for the comparatively poor plankton generally found off this side of the island when the spring maximum is over, as no nutritious waters from the depths are carried to the surface in the summer.

The west coast consist to a great extent of the two large bays Faksebay and Bredefjord. The former alone was investigated on the cruise of the "Dana". The depth as regards the greater part of the bay is less than 50 m. One would therefore not suppose that it was neccessary for the surface water to be stabilized for a plankton production to start in the spring. In calm weather it is also to be supposed that a plankton production might occur here as early as the beginning of April. The investigations in the beginning of May 1934 show that earlier in the year a production must have taken place in the bay, at any rate in the inner shallow part of it. Both the small quantity of nutritive salts at St. 5094 off Akranes (table 4, page 11) and the relatively large quantity of plankton at a depth of 25 m (table 5, page 11) at the same station, support the above statement. The production in the Fakse-bay was, presumably, interrupted by stormy weather which resulted in the accumulations at the bottom of the sea being whirled up in the water thus reducing the transparency. When the "Dana" visited the Fakse bay in the beginning of May 1934 the transparency of the water was slight (vide page 47).

Apart from the inner shallow portions of the bays on the west coast, where under quiet weather conditions the plankton production may start quite early in the season, it does not commence here, just as off the south coast, until some time in May when the surface water has become stabilized (vide page 47 and table 5, page 11). During the spring maximum the plankton off the west coast corresponds very well with that which at the same time is found off the south coast; the production is very vigorous; here also the diatoms dominate (table 16, page 18).

About the 1st July, or may be sometimes much earlier, the production has culminated, the nutritive salts in the surface layers have been consumed and the plankton is sinking. After this one finds a generally rather poor plankton (vide for instance St. 4451, table 19, page 20). We now find the summer-peridinian-plankton described by Paulsen (1904 and 1910). Besides *Peridinium triquetrum* the coccolithophorid *Pontosphaera huxleyi*, however, plays the principal part among the producers. Furthermore a lot of small naked heterotrophic flagellates are

found (table 19, page 20). At the outer stations as for instance St. 4452 at Skagi, however, one generally finds a rather rich plankton though the nutritive salts have now disappeared from the surface here as well. The plankton, however, is rather oceanic in character, the little coccolithophoride *Pontosphaera huxley* being almost the only producer. This plankton is doubtless conditioned by supplies from the adjacent Irminger Stream, now rich in plankton.

From the banks south of Iceland, a supply can, however, sometimes be made to the southernmost part of the west coast during the summer; at the St. 24 in this particular area, Hentschel (1933) found a rich diatom plankton in August which was similar to that on the banks south of Iceland. This is exactly what one might expect considering the direction of the current.

While the coastal water along the west coast of Iceland, just as on the south coast, is firmly stabilized in the summer, there is up at Staalbjerghuk, constantly, a very strong tide race which is contingent on the tidal wave from the south in conjunction with the volumes of water which at the same time gush out from Bredefjord (vide "Den islandske Lods" 1911, page 29). At the somewhat more northerly points Ritr, Straumnes and Kogr such tide races are also to be found occasionally. However, during the times the "Dana" made investigations here only the tide race at Staalbjerghuk was distinct. In these eddies the nutritious water from the depths is carried up to the surface (vide St. 4427 and St. 4454 at Staalbjerghuk, tables 17 and 19, page 19 and 20). However, at Staalbjerghuk no vigorous plankton production seems to have resulted from the supply of nutritive salts to the surface which must be due to the vertical movements in conjunction with the intransparent state of the water owing to the stirring up of the deposits at the bottom (vide page 49).

The very rich diatom plankton consisting principally of *Chaetoceros* species which was found at the northwest corner of Iceland at the end of July 1932, is on the contrary, possibly contingent, to some extent, on the supply of the nutritious deep water in the eddies to the surface; the supply here of nutritious water from the Denmark Strait, however, plays, presumably, the most important part (vide table 21, page 22).

It is presumably not every year that such a vigorous plankton maximum of diatoms is found at the northwest corner of Iceland at the height of summer as at the end of July 1932. Paulsen's qualitative investigations in the area do not seem to point in that direction (Paulsen 1904 and 1909). When the "Dana" at the beginning of August 1933 made investigations here a comparatively poor plankton was found (vide table 38, page 36); the coccolithophoride *Pontosphaera huxleyi* was, however, observed in large quantities. The same was the case in August 1932 according to Hentschel (1933).

Investigations into the plankton production at the northwest corner of Iceland have not been made in spring and early summer. However, it may doubtless be reckoned that the production sets in at somewhat the same time as towards the south. According to Paulsen (1909), however, the plankton consists partly of other species which is due to the admixture of cold water of poor salinity from the Denmark Strait.

c. The North Coast of Iceland.

Quantitative investigations of the plankton off the north coast of Iceland have not been made in the spring. But Paulsen's (1904 and 1909) plankton tables give fairly good information. As far as can be deduced from the frequency records of the species in the samples taken at Rodehuk and Gjogurta, the production — just as at the south and west coast — must set in some time during May. It is certain that here also the appearance of the stabilization determines

when the production is to begin. From the end of May till some time towards the close of June there is no doubt that a vigorous production of plankton takes place off the north coast of Iceland.

The coastal water at the north coast of Iceland is partly of Atlantic origin as there is a pronounced movement of the waters on the coasts, around Iceland in the direction of the hands on a clock. But from about Kap Nord there is a distinct admixture of colder water which must be due to admixture of water from the Denmark Strait. Beyond the coastal water, north of Iceland, one meets with typically arctic water, a blend of Atlantic and polar origin, which is found in the central part of the Norwegian Sea. Under the light, less salty, warm coastal water in the surface layers, arctic water is also, as a rule to be found. Just beyond the actual coastal water there is, as a rule, comparatively unmixed Atlantic water in the shape of a branch of the Irminger Current which forms an intermediate layer having a salinity above 35.00 $^{0}/_{00}$ (Helland-Hansen and Nansen 1909). However, there are certainly, as already mentioned, but insignificant quantities of Atlantic water that in that way are carried into the Norwegian Sea.

The coastal water at the north coast of Iceland, owing to the very perceptible admixture of colder water, has a qualitative somewhat different plankton from those off the south and west coasts. This is particularly evident during the spring maximum, for according to Paulsen (1904 and 1909) a long range of the diatoms which at this time are so common off the south and west coasts, as for instance, *Asterionella japonica*, do not occur at all off the north coast. The species most commonly met with during the spring maximum, as only the somewhat larger organisms caught in silk nets are taken into consideration, are according to Paulsen (1909) particularly *Thalassiosira*-species.

During the spring maximum the phosphates and nitrates in the surface layers are completely consumed. After the rich plankton production which most probably continues till some time towards the middle of June, the coastal water north of Iceland — at any rate in the central part — is generally very poor as regards production. This proved to be the case when the sample L 1 at the end of June 1933 was collected (table 46, page 41), in July 1932 (table 22, page 22) and August 1933 (table 37, page 35) when the "Dana" made investigations here and in August 1932 when Hentschel made quantitative determinations of the plankton in this area (vide St. 30—St. 35 in table 2, page 266, by Hentschel 1933).

Just off the coast there are many places where the surface is, at times, supplied with nutritious water from the depths, as stated by both Nielsen (1905) and Buch (1934). On the greater part of the coast this appears to be of merely local significance; any actual production on the coastal banks does not seem to be the result. Doubtless only very small volumes of water are in this way carried up to the surface. The upwelling of the bottom water is a result of definite wind conditions.

It has already been stated that sometimes in summer a very rich plankton is found at the north west corner of Iceland. Something similar appears to be the case at the northeasterly corner of the island as well, for on the "Dana" cruises both in July 1932 (table 23, page 23) and August 1933 (table 36, page 35) and in accordance with Hentschel (1933) in August 1932 (St. 36) a plankton, rich in comparison to the poverty at the central part of the north coast, was found. The diatom *Nitzschia delicatissima* is the dominating species. The plankton production here must, presumably, be ascribed, to some extent, to the supply of nutritive salts to the surface in the strong tide races at Raudagnupr and Langanes. According to "Den islandske Lods" (1911) these are at times exceedingly strong. Moreover vertical movements most probably take place when the arctic current from the north comes over the shelf.

In the tide races themselves, as long as they are strong, there are only unfavourable conditions for the plankton production (the transparency of the water is doubtless low owing to the stirring up of the deposits at the bottom). This is evidenced by the poorness of the plankton at St. 4474 (table 23, page 23), which found itself in the middle of the strong tide race at Langanes, though the surface water here was very rich in nutritive salts.

d. The East Coast.

During the winter the convection currents, as they do everywhere at the coast of Iceland, bring about a powerful vertical mixing. When the "Dana" visited East Iceland in the middle of May 1934 the surface water was not stabilized (vide table 4, page 11). The plankton production had not generally begun (tables 8 and 9, page 13); only at some places just off the coast where the water was rather shallow, there was found, as early as this, a fairly rich plankton (St. 5116). The weather conditions had generally been very unsettled in May.

Any particularly firm stabilization in summer is not, however, generally found on the whole east coast. The current on the whole is very strong which is due to the cooperation of the tide water current with the sea current proper. Beyond projecting points, therefore, strong tide races are often formed particularly by northerly and southerly storms. This, as already mentioned, was also the case off Langanes.

In the summer the arctic current from the north, which is known as the East Iceland Current, is, on the northernmost part of the east coast, generally an undercurrent below the coastal water warmed up during the summer. This water originates partly from the north coast of Iceland. But further south the arctic current gets the upperhand entirely. Therefore while the production off the most northerly part of the east coast, when the maximum during the early summer has consumed the nutritive salts in the surface water, generally is very small (table 35, page 34), we find, on the contrary, further south where the fairly nutritive arctic water has come up to the surface generally a distinct plankton production throughout the summer (tables 24 and 34, pages 24 and 34). Where eddies exist, as outside the Seydisfjord (St. 4479, table 24, page 24) the production is, however, as a rule very small owing to the vertical currents in conjunction with the probably low transparency of the water. The plankton in the arctic water has a distinctly oceanic character which in 1932 was manifested by the quantity of the little oceanic diatom *Fragilaria nana* (vide e.g. St. 4480, table 24, page 24).

The hydrographic conditions at East Iceland are, however, subject to great variations as the arctic water, at times, dominates in the surface water from almost as far up as Langanes (July 1932) while at other times, as was the case at the end of July 1933, it does not come up to the surface till so far south as off Kambanes.

Between Eystrahorn and Vestrahorn the East Icelandic Current encounters the Atlantic water. It is only when we reach so far south as this mixing area that we find a really vigorous plankton production throughout the summer. Though sometimes, at all events, powerful vertical movements must take place during the mixing processes — this is how the nutritive salts come up to the surface — things must, however, at other times be so calm that conditions for the very vigorous production exist. It must also be taken into consideration that the depth here is not particularly great. The plankton consists almost exclusively of diatoms but the composition of the species varies greatly. Both, species characteristic of the north, such as *Chaetoceros furcellatus* and southerly species such as *Asterionella japonica*, are among those that dominate (vide table 26, page 25, and table 33, page 33).

When the very first production sets in, in May, the conditions for it, apart from the

difference in temperature, are somewhat the same in the arctic and the atlantic coastal water and this is made evident by the fact that the composition of the plankton is now approximately the same in the two varieties of water (cpr. page 14).

e. The Icelandic Fjords.

When discussing the plankton production on the west coast, it was mentioned that in the inner shallow part of the Fakse-bay with calm weather conditions, it can begin a deal earlier than out on the open coastal banks. This is to a very much greater extent the case in the Icelandic fjords. It may be safely reckoned that the production begins here about a month earlier that outside in the open coastal water. Thus in the Rødefjord on the east coast a rich plankton was found when the "Dana" called there in May 1934 (table 8, page 13), while outside, the production generally hardly had begun.

After the spring maximum in the fjords, provided a fresh lot of nutritive salts is not supplied from outside, a rather poor time for the plankton will supervene. In most of the fjords in question a comparatively energetic exchange takes place with the coastal water outside, owing to the strong tidal currents. If, as is generally the case outside the Seydisfjord, there is comparatively nutritious water beyond the fjord, nitrates and phosphates may possibly be carried into it by the tidal current. A supply of this kind was, no doubt, the main cause of the very vigorous plankton production which appeared here at the end of July 1932 (table 25, page 24).

However, high values for the nitrate and phosphate contents are by no means found in the surface water outside all the Icelandic fjords. In most of them, however, one must reckon on a fairly small supply of nitrates and phosphates by the fresh water from the land. In August 1933, the plankton production at the bottom of the long Oford on the north coast (table 75, appendix) was certainly contingent on a supply of fresh water from land. The small quantities of nutritive salts right at the surface are consumed immediately. Only in the rather fresh water, immediately at the surface, is phyto-plankton found. A similar state of things existed in the Patrichsfjord and Ønundafjord in July 1932 (table 20, page 21). During the summer no really large plankton production will, however, ever be found in the fjords where the supply of nutritive salts comes solely from the land. Approximately the same species are generally found inside the fjords as in the coastal waters outside.

9. The Central "Arctic" part of the Norwegian Sea.

In the sea to the east of Iceland, quantitative plankton investigations were made on the cruise of the "Dana" at the end of May 1934. The water here consists of what is known as "arctic" water i. e. a mixture of Atlantic water the greater part of which has originally come into the Norwegian Sea through the Faroe-Shetland Channel, and polar water from the East Greenland Stream (vide Helland-Hansen and Nansen 1909).

The surface water was at the end of May just about to become stabilized and the plankton production to start (table 9, page 13, and table 76, appendix). The coccolithophoride *Coccolithus pelagicus* dominated in the plankton. In addition most of the species which are also characteristic of the plankton in the most northerly part of the Atlantic were found and finally, in small quantities, some neritic species such as *Chaetoceros debilis*.

The spring maximum in the central part of the Norwegian sea will, presumably, correspond approximately to that in the most northerly part of the Atlantic, at any rate from a

purely productive point of view; the proportion as regards quantity between the individual species will very possibly vary. Unfortunately quantitative plankton investigations, subsequent to May, in this area are not available. It can therefore only theoretically be concluded that the spring maximum, like that in the most northerly part of the Atlantic, very likely culminated about the 1st of July. Gran (1929) found a poor plankton here in the middle of July 1924. *Coccolithus pelagicus* was the predominant species. Further investigations in this area are urgently required.

Chapter VIII.

Problems. Phytoplankton production and fish populations.

As is evident from what has already been stated, the conditions for production are of a very diverse character in the different sea areas around Iceland and the Faroe Islands. The factors that are of importance for the plankton production do not act in the same way everywhere, and it is only when they act together as a harmoneous whole that the possibilities of production are optimal. A typical example of this is the vertical mixing. While this factor in one particular area is the main reason for an exceedingly rich production of plankton, as for instance in the mixing area between the Irminger and East Greenland currents (vide page 58), in other places it is, on the contrary, a positive hindrance to any production whatever, as for instance during the spring out on the open ocean (vide page 51).

It will therefore be of the very greatest importance to have thorough investigations instituted regarding the vertical movements of the volumes of water in the sea. We are, it is true, already in a position to prove that such vertical movements take place, but how they actually occur, how rapidly the processes take place are still comparatively unsolved problems. In the uppermost productive layers for plankton production rather extensive vertical movements must, however, take place, also beyond the areas where such movements are pronounced. Among other things that point to this is the, as a rule, regular distribution of plankton algae in the waters above the discontinuity layer, and furthermore the circumstance that the increase of the oxygen content in the sea during a period of production does not as a rule nearly correspond to the increase one might expect after simultaneously conducted investigations of respiration and CO_2-assimilation in water which has been confined in glass bottles. Slow vertical movements must as a rule take place in the upper layers whereby the entire mass of water comes, more or less in contact with the atmosphere.

Not only as a mean of understanding the conditions for production, but also of understanding the mechanism with regard to the floating of the motionless algae, a more exact study of the vertical movements of the water volumes would be exceedingly valuable.

It would likewise be of great importance to institute systematic investigations regarding the transparency of the sea all the year round. With the modern methods now available this could be done. A list of literature regarding these methods is to be found by Pettersson and Landberg (1934). Furthermore the Pulfrichphotometer admits of being used in the way shown in this paper, page 45.

In the introductory chapter stress was laid on the fact that these investigations regarding the production of phytoplankton were to be regarded as a link in the investigations of the chain of factors leading to the production of great fish populations. It will therefore be of interest to enquire whether the areas with large productions of phytoplankton and those with great

fish populations are identical. In the chart 5, page 72, is given a synopsis of the distribution of the areas regarding the size of the phytoplankton production. The area with the presumably very largest annual plankton production, the banks on the south coast of Iceland west of the Vestman Islands, is the site of one of the worlds very largest fisheries. Now, however, it is not to be expected that the result of a large production of phytoplankton on the stock of fish will always show itself in the same place. It is true that on the south coast of Iceland the

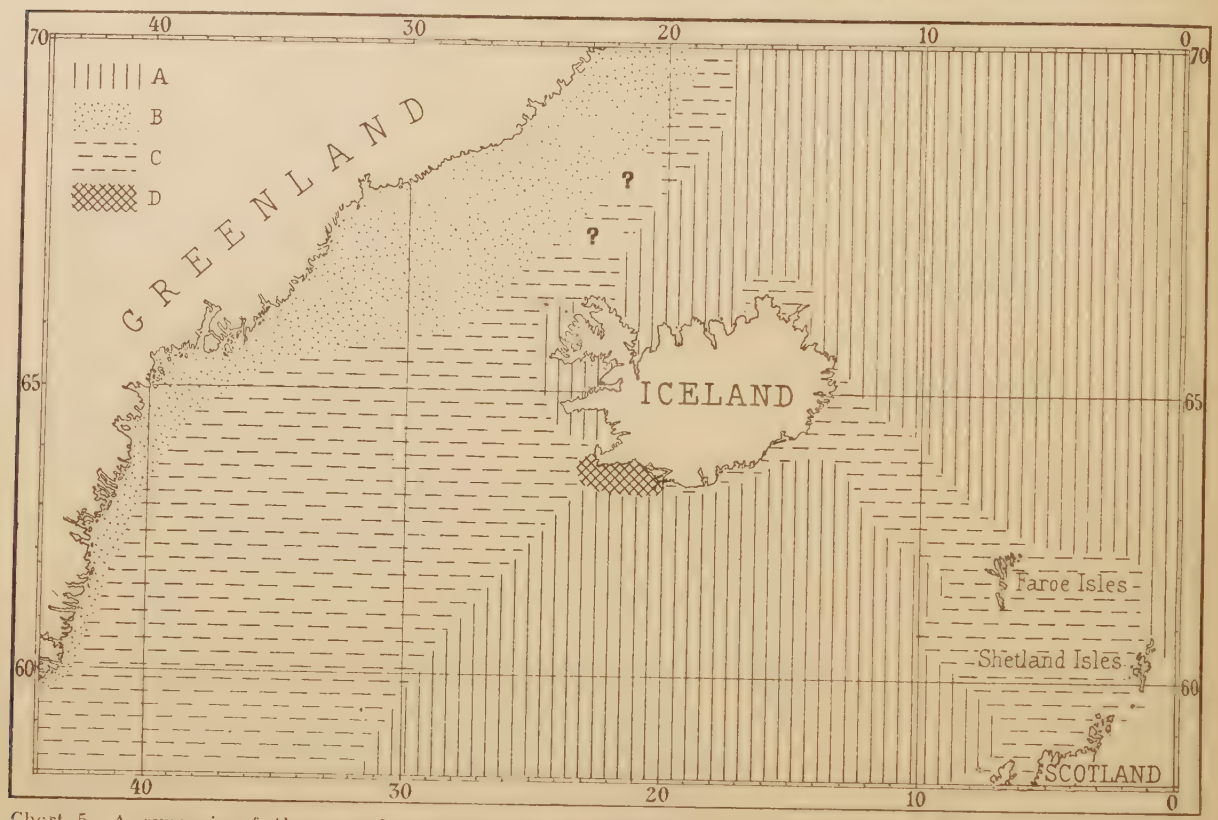

Chart 5. A synopsis of the annual production of phytoplankton in the various areas. A. Vigorous production in May-June; at the other times of the year but very little production. B. Vigorous production in June-July, at the other times of the year but very little production. C. Considerable production from May (in the Irminger Sea from the beginning of June) during the whole summer. The statement of an area with production of phytoplankton during the whole summer along the border of the East Greenland Current north of the Denmark Strait is perhaps not true. Investigations in late summer here are lacking.[1]) D. Vigorous production from May during the whole summer.

result of the large phytoplankton may be expected to show itself in the same place as the current here isn't particularly strong (vide "Den islandske Lods" 1911, p. 31), but it does not follow that this need be the case elsewhere. Thus the large quantity of herrings, which during the summer are found on the north coast of Iceland, need by no means be at variance with the usually rather small phytoplankton production here. For herrings, at any rate the adults, do not live directly on phytoplankton, but, on the contrary — at any rate on the north coast of Iceland — almost exclusively on the copepod, *Calanus finmarchicus*. Large quantities of this

[1]) It is however to be assumed that the deep water of the Norwegian Sea here is pressed upwards to a slight degree. This perhaps effects just as in the Irminger Sea vertical mixing processes, although in a much smaller degree.

copepod are found on the north coast of Iceland during the summer. The main part of these huge masses could not, however, have grown up here, but must, it is presumed, have drifted here with the current (vide PAULSEN 1906), which on the north coast of Iceland has a very distinct direction like the hands of a clock. These quantities of *Calanus finmarchicus* must, it is assumed, be derived from the south and west coast of Iceland, perhaps, to some extent, also from the Denmark Strait. In any case they are not produced on the north coast of Iceland. There need therefore be no relation whatever between the quantity of herrings and the production of phytoplankton on the north coast of Iceland; on the contrary the herrings are dependent on a phytoplankton production of quite other places viz. where the huge numbers of *Calanus finmarchicus* have grown up. It will here be recognized, as already pointed out in the introduction, how complicated is the state of dependence between the phytoplankton production and the fish populations.

The annual fluctuations as regards the occurrence of the production period for the phyto-plankton are no doubt, very often of great significance in respect of the production of the various species of fish. If, for instance, a certain species, during one period of its development, feeds on phytoplankton it is to be assumed that an entire year-class of that species would — more or less — be ruined should the period for the phytoplankton production be delayed or perhaps accelerated in relation to the plankton-consuming stage of the species in question. As the factors which determine the spawning period for the fish and those which effect the starting of the phyto-plankton production do not, to a great extent, synchronize, there must certainly be occasional "irregularities in the accounts" in nature. To be able to follow the annual course of the plankton production would doubtless be of great importance for the fishery investigations.

As a means of understanding the distribution of various fish and other animals which at a certain stage of development live on phyto-plankton, an accurate knowledge of the time for the plankton production in the different areas would be of importance. A retarded time for the commencement of the phytoplankton production as shown in this paper with regard to the Icelandic coastal stretches as compared with the otherwise fairly similar Norwegian coastal stretches, is perhaps the very factor that determines that a particular species of animal has not the possibilities of existence.

In several ways an accurate knowledge of the course of the phytoplankton production would be of exceeding importance.

The manuscript is translated from Danish by Mr. S. LISSANT. I am however much indebted to Dr. T. BRAARUD, Oslo, for kindly looking through the translation.

Appendix.

A description of *Fragilaria nana* nov. spec.

In the foregoing only the quantitatively most important species have been taken into consideration. As far as possible all species were determined in the samples (vide the tables in the appendix). As regards the nanno-organisms the records will be used in a comprehensive work on the plankton algae at Iceland, as the leader of the plankton laboratory, Dr. phil. Ove Paulsen is about to undertake a thorough qualitative working up of the microplankton in the net samples collected at the same time as the quantitative samples.[1])

Fig. 2. *Fragilaria nana* nov. sp. (1800 ×). *a.* valve view, *b.* girdle view of a colony (St. 4508).

No special treating of the different species is, therefore, made in this paper. A single exception is, however, a small not previously described diatom which is very common in several areas. It is placed in the genus *Fragilaria*. It forms colonies with generally 2 or 3 individuals. The valves are linear with rounded corners. The apical axis 4—8.5 μ, the transapical axis 1.5—2 μ, the pervalvar axis about 2 μ. There are two chromatophores, one on each side of the transapical axis, no structure could be observed on the valves.

Fragilaria nana is an oceanic species which prefers eutrophic water with a temperature of about 10° C. In the area here dealt with the species is therefore found mostly during the height of summer in the Faroe-Shetland Channel, the Irminger Sea and over the ridge between Iceland and the Faroe Islands.

[1]) Furthermore the author intends to give a geographical survey on the phytoplankton of the Northern Atlantic.

Appendix. Table 56.

elected representative station (St. 4402) showing the plete composition of the plankton in the northern th Atlantic during the spring maximum (values per 100 ccm).

th in m	0	10	25	50
perature in ° C	11.57	11.45	11.35	9.33
nity, ‰	35.34	35.32	35.32	35.32	
	26.95	26.95	26.97	27.32
, mg/m³	0	5	5	50
, mg/m³	20	20	20	150
perc. of sat	107.2	107.2	105.6	92.3
idinians.				
ymnodinium sp.	5,000	10,100	2,800	400
rorocentrum micans	10	..	20	..
xuviaella baltica	30	120	20	..
halacroma rotundatum	10	10	..	..
inophysis acuta	10	..	10	10
linuscula bipes	200	..	..	..
iplopsalis sp.	20	..	..	..
eridinium brevipes	..	20	..	..
— depressum	20	..	..	..
— ovatum	10	..	..	..
— sp.	10	..	..	10
eratium horridum	..	10	10	..
— lineatum	10	..	..	..
— furca	10	..	..	10
— fusus	..	20	10	10
atoms.				
oscinodiscus sp.	..	40	70	60
halassiosira sp.	200	1,200	900	..
hizosolenia semispina	200	270	270	20
— styliformis	30	10	40	30
haetoceros laciniosus	..	..	90	..
teres	10	..	..	..
— sp.	120	60	..	..
Nitzschia delicatissima	3,600	570	960	..
— seriata	..	90	40	30
Navicula sp.	30	100	70	10
halassiothrix nitzschioides	..	..	30	..
ccolithophorides.				
Pontosphaera huxleyi	76,000	88,000	63,200	4,800
Syracosphaera sp.	9,800	10,800	12,400	1,200
Coccolithus pelagicus	..	1,200	50	..
Michaelsarsia sp.	400	400	..	..
Acanthoica bispinosa	..	800	800	..
agellates.				
Different naked species	5,200	12,800	4,000	2,000
fusorians.				
Lohmanniella oviformis	50	50	30	10
Mesodinium rubrum	..	..	20	..
Laboea conica	180	70	50	..

Table 56 (continued).

Depth in m	0	10	25	50
Laboea strobila	20	..	..	..
vestita	..	40	..	..
Acanthostomella norvegica	60	90	30	..
Parafavella dentata	40	30	20	..
Infusorian sp.	400	30	10	10

Appendix. Table 57.

A selected representative station (St. 4508) showing the complete composition of the plankton in the Faroe-Shetland-Channel during summer (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	11.75	11.70	11.53	10.12
Salinity, ‰	35.29	35.28	35.31	35.34
σ_t	26.87	26.87	26.93	27.21
P_2O_5, mg/m³	25	30	..	45
N_{NO_3}, mg/m³	70	65	..	150
O_2, perc. of sat	102.0	..	100.7	93.8
Peridinians.				
Amphidinium sphenoides	50	30	40	..
Gymnodinium sp.	9,200	6,500	4,400	800
Exuviaella baltica	90	70	..	..
Dinophysis acuta	20	..	10	10
Ceratium furca	10	..	10	..
— tripos	10	20	..	10
Diatoms.				
Dactyliosolen mediterraneus	50	20	..	30
Chaetoceros concavicornis	50	30	20	..
— sp.	10	..	..	..
Fragilaria nana	10,400	8,400	12,800	1,200
Nitzschia delicatissima	800	1,200	2,000	70
— closterium	1,600	800	800	..
Coccolithophorides.				
Pontosphaera huxleyi	29,200	24,400	20,000	1,600
Syracosphaera sp.	3,200	4,400	4,000	400
Coccolithus pelagicus	60	40	80	30
Flagellates.				
different naked species	76,800	60,200	42,400	9,200
Infusorians.				
Lohmanniella oviformis	10	20	10	..
Laboea conica	20	30	10	..
— sp.	30	40	20	..
Infusorian sp.	40	20	20	10

Appendix. Table 58.

A selected representative station (St. 4487) showing the complete composition of the plankton in the Gulf Stream area over the ridge between Iceland and the Faroes during summer (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	9.50	9.38	9.30	8.92
Salinity, ‰	35.07	35.08	35.08	35.11
σ_t	27.11	27.11	27.15	27.23
P_2O_5, mg/m³	30	30	30	40
N_{NO_3}, mg/m³	75	60	60	90
O_2, perc. of sat.	98.4	..	98.0	96.0
Peridinians.				
Amphidinium sp.	..	20	10	30
Gymnodinium lohmanni	..	..	20	..
— sp.	1,730	1,210	860	130
Pronoctiluca pelagica	10	..	20	20
Exuviaella baltica	..	..	20	..
Minuscula bipes	10	20	200	..
Diatoms.				
Thalassiosira sp.	100	40	..	..
Rhizosolenia semispina	20	..	..	..
Chaetoceros furcellatus	80	210	100	90[1]
— concavicornis	..	20	..	..
— gracilis	..	..	10	..
Eucampia groenlandica	150	70	340	130
Corethron criophilum	..	..	30	20
Nitzschia closterium	..	..	..	10
— delicatissima	380	420	390	480
Fragilaria nana	2,800	2,400	1,600	2,000
Thalassiothrix nitzschioides	..	..	..	40
Navicula sp.	..	40	40	10
Coccolithophorides.				
Pontosphaera huxleyi	7,200	3,200	5,200	2,000
Syracosphaera sp.	..	100	..	..
Coccolithus pelagicus	20	40	160	90
Flagellates.				
Distephanus speculum	..	10	..	..
different naked species	29,600	23,200	10,800	8,000
Infusorians.				
Lohmanniella oviformis	..	..	20	20
— spiralis	..	..	..	10
Mesodinium rubrum	20	20	..	20
Laboea conica	..	20	..	..
— sp.	10	70	..	..
Acanthostomella norvegica	..	..	10	..
Parafavella dentata	10	20	..	..
Infusorian sp.	60	40	60	20

[1]) partly with restingspores.

Appendix. Table 59.

A selected representative station (St. 4447) showing complete composition of the plankton in the Irminger in July (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	9.13	9.18	8.48	8.0
Salinity, ‰	35.04	35.06	35.08	35.0
σ_t	27.15	27.15	27.28	27.3
P_2O_5, mg/m³	20	10	30	40
N_{NO_3}, mg/m³	90	75	90	90
O_2, perc. of sat.	102.5	103.0	98.8	94.1
Peridinians.				
Amphidinium sphenoides	20	20	20	10
Gymnodinium lohmanni	80	..	..	..
— sp.	820	880	840	320
Paulsenella chaetoceratis	..	..	20	20
Dinophysis acuta	40	130	10	..
Goniaulax spinifera	20	60	..	..
Diplopsalis asymmetrica	..	..	10	..
Peridinium brevipes	100	..	..	..
— pellucidum	60	160	..	..
— sp.	40	20	10	20
Ceratium fusus	..	10	..	..
lineatum	..	40	..	..
Diatoms.				
Asteromphalus heptactis	..	10	20	10
Thalassiosira gravida	..	..	60	..
— sp.	20	20	60	20
Rhizosolenia alata	60	80	100	130
— delicatula	..	100	200	..
— semispina	..	40	..	80
Chaetoceros affinis	100	..	60	..
— atlanticus	840	920	460	..
— borealis	140	160	10	40
— concavicornis	280	600	960	90
— densus	..	..	1,000	..
Eucampia groenlandica	..	..	150	..
Corethron criophilum	160	100	300	10
Nitzschia closterium	20	60	80	..
— delicatissima	123,200	129,600	140,800	1,250
Fragilaria nana	1,200	2,000	2,400	160
Thalassiothrix longissima	140	120	100	60
Navicula sp.	10	..	20	..
Coccolithophorides.				
Pontosphaera huxleyi	..	..	..	100
Coccolithus pelagicus	..	..	..	20
Flagellates.				
different naked species	9,600	14,800	10,000	9,200
Infusorians.				
Lohmanniella oviformis	..	..	..	10
Mesodinium rubrum	20	..	..	..
Laboea conica	100	220	20	..

Table 59 (continued).

in m	0	10	25	50
...bea sp.	40	100	20	10
...nthostomella norvegica	..	10	20	..
...afavella dentata	20	10	..	..
...chocylis urnula	30	..	..	..
...isorian sp.	..	40	..	10

Appendix. Table 60.

...lected representative station (St. 4686) showing the ...plete composition of the plankton in the Southwestern ... of the Irminger Sea in August (values per 100 ccm).

...h in m	0	10	25	50
...perature in ° C.	10.97	10.91	9.57	7.20
...ity, ‰	35.01	35.01	35.04	35.10
...	26.81	26.82	27.07	27.19
..., mg m³	40	30	..	..
...dinians.				
...phidinium sphenoides	2,000	3,200	30	10
— sp.	400	..	..	..
...mnodinium sp.	7,600	12,800	3,960	420
...noctiluca pelagica	..	..	70	..
...uviaella baltica	..	..	..	10
...nophysis acuta	30	20	20	10
...miodoma ostenfeldii	10	20	10	..
...ridinium brevipes	60	110	40	..
— pellucidum	..	..	10	..
triquetrum	..	50	..	..
sp.	10	20	..	..
...ratium fusus	150	300	70	20
lineatum	150	110	10	..
longipes	..	10	10	..
...atoms.				
...scinodiscus sp.	..	..	10	..
...halassiosira bioculata	..	50	..	..
— decipiens	220	300	100	20
sp.	..	60	30	10
...actyliosolen mediterraneus	1,170	2,580	170	20
...hizosolenia alata	110	30	30	..
— semispina	70	10	10	10
...haetoceros concavicornis	30	..	..	..
...erataulina bergonii	..	70	170	..
...ucampia groenlandica	2,400	1,600	80	..
...itzschia closterium	..	40	30	..
— delicatissima	3,600	9,200	6,000	1,600
...ragilaria nana	1,200	3,600	..	30
...halassiothrix longissima	10	..	10	..
...avicula sp.	50	30	70	..
...ccolithophorides.				
...ontosphaera huxleyi	10,400	9,600	1,200	800
...yracosphaera sp.	4,800	3,200	90	10

Table 60 (continued).

Depth in m	0	10	25	50
Coccolithus pelagicus	4,000	1,200	1,600	20
Rhabdosphaera stylifer	..	800	..	..
Acanthoica quatrospina	40	10	10	..
Ophiaster hydroideus	800	1,200	..	..
Coccolithophorid sp.	2,400	1,200	400	800
Flagellates.				
different naked species	70,400	104,400	26,800	3,200
Infusorians.				
Globigerina sp.	10	..	..	..
Lohmanniella oviformis	..	..	20	..
spiralis	80	120	..	..
Laboea conica	30	30	..	..
sp.	40	70	10	..
Acanthostomella norvegica	10	..	..	..
Tintinnus lusus undae	30	110	..	..
Infusorian sp.	80	100	10	10

Appendix. Table 61.

A selected representative station (St. 4659) showing the complete composition of the plankton in the Northeastern part of the Irminger Sea in August (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in C	11.31	11.30	11.29	8.70
Salinity, ‰	35.04	35.03	35.01	35.10
σ_t	26.77	26.76	26.76	27.27
Peridinians.				
Amphidinium sphenoides	30	20	60	..
Gymnodinium sp.	4,400	3,960	1,750	410
Dinophysis acuta	40	20	20	10
Phalacroma rotunda	20	10	20	..
Goniaulax spinifera	..	20	..	..
Peridinium brevipes	20	40	20	..
— depressum	40	..	..	..
ovatum	..	10	..	..
— triquetrum	..	20	20	..
— sp.	..	..	..	10
Ceratium lineatum	60	40	30	..
— tripos	40	40	10	..
Podolampas palmipes	..	..	..	10
Diatoms.				
Dactyliosolen mediterraneus	1,900	3,100	740	160
Thalassiosira decipiens	50	60	60	50
— sp.	10	30	10	30
Rhizosolenia semispina	..	10	..	..
Chaetoceros pelagicus	..	..	..	170
Cerataulina bergonii	..	20	..	20
Nitzschia closterium	..	..	10	10
— delicatissima	..	10	380	1,530

Table 61 (continued).

Depth in m	0	10	25	50
Nitzschia seriata	..	..	..	50
Thalassiothrix longissima	..	..	..	270
Fragilaria nana	80	..	..	40
Coccolithophorides.				
Pontosphaera huxleyi	1,200	1,600	400	..
Syracosphaera sp.	220	280	230	40
Coccolithus pelagicus	3,600	3,200	2,950	960
Rhabdosphaera stylifer	10	..	..	..
Acanthoica quattrospina	30	..	10	..
Flagellates				
different naked species	8,800	5,200	3,320	900
Infusorians.				
Globigerina sp.	..	10	..	20
Lohmanniella oviformis	..	..	..	10
Parafavella dentata	..	10	10	10
Ptychocylis urnula	..	..	10	10
Dictyocysta elegans	..	..	10	..
Infusorian sp.	20	30	..	..

Appendix. Table 62.

A selected representative station (St. 4432) showing the complete composition of the plankton in the East Greenland Polar current during the maximum in the early summer (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	0.60	0.68	—0.56	—1.01
Salinity, ‰	32.92	33.13	33.60	33.95
σ_t	26.42	26.58	27.00	27.28
P_2O_5, mg/m³	10	10	20	40
N_{NO_3}, mg/m³	0	0	40	80
O_2, perc. of sat.	99.2	101.6	99.1	88.8
Peridinians.				
Amphidinium sp.	..	10	..	..
Gymnodinium lohmanni	..	..	10	120
— sp.	260	510	180	700
Exuviaella baltica	40	30	..	..
Phalacroma rotundatum	..	20	..	..
Peridinium ovatum	..	..	10	20
— sp.	10	30	..	20
Oxytoxum belgicae	..	10	..	10
Diatoms.				
Coscinosira polychorda	..	..	..	50
Thalassiosira gravida	440	570	1,280[1])	1,230
— nordenskjöldii	660	570	40	180[1])
— subtilis	..	..	120	..
— sp.	330	380	70	120
Bacteriosira fragilis	..	..	90	..

[1]) partly with restingspores.

Table 62 (continued).

Depth in m	0	10	25	50
Rhizosolenia alata	..	20	50	..
— semispina	90	80	50	..
styliformis	..	10	30	..
Chaetoceros borealis	30	40	50	..
— concavicornis	30	60	40	..
— decipiens	..	..	50	..
furcellatus	2,560[1])	2,660	770[1])	250
— gracilis	20	50	..	..
— sp.	..	..	60	..
Eucampia groenlandica	10	..	..	..
Nitzschia delicatissima	1,290	2,000	9,600	2,100
Fragilaria islandica	..	30	..	..
nana	..	110	..	..
— oceanica	740	800	250[1])	150
Navicula pelagica	60	..	60	..
sp.	20	..	..	..
Coccolithophorides.				
Coccolithus pelagicus	..	30	10	..
Flagellates.				
Phaeocystis pouchetii	53,200	140,000	880,000	284,000
Choanoflagellate sp.	400	400	400	400
Halosphaera viridis	..	..	..	50
different naked species	2,000	4,400	3,200	2,000
Infusorians.				
Lohmanniella oviformis	70	80	100	110
— spiralis	..	20	..	..
Mesodinium rubrum	10	210	10	10
Laboea conica	340	40	..	..
— strobila	10	60	..	..
sp.	180	60	..	..
Acanthostomella norvegica	10	20	..	20
Ptychocylis urnula	10	10	..	..
Infusorian sp.	30	40	..	..

Appendix. Table 63.

A selected representative station (St. 4436) showing the complete composition of the plankton in the mixing area between the East Greenland Polar current and the Irminger current during the summer (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	3.96	4.49	8.24	8.23
Salinity, ‰	33.84	34.15	35.06	35.04
σ_t	26.89	27.08	27.30	27.29
P_2O_5, mg/m³	10	15	25	30
N_{NO_3}, mg/m³	5	50	90	80
O_2, perc. of sat.	104.8	102.0	97.6	97.4
Peridinians.				
Amphidinium sphenoides	..	..	20	..
Gymnodinium lohmanni	30	140	140	140

Table 63 (continued).

th in m	0	10	25	50
mnodinium sp.	80	800	1,200	800
alacroma rotundatum	..	20	..	..
— sp.	..	10	..	..
ulsenella chaetoceratis	..	..	200	40
nophysis acuta	..	60	20	..
niaulax spinifera	..	20	..	..
muscula bipes	10	..	..	..
ridinium brevipes	20	40	..	..
— ovatum	..	20	..	..
— roseum	..	40	..	..
— sp.	..	..	80	60
xytoxum belgicae	..	..	20	..
atoms.				
steromphalus heptactis	..	..	20	20
oscinosira polychorda	20	..	..	..
nalassiosira gravida	850[1])	2,120	120	80
nordenskjöldii	..	60	..	..
— sp.	..	200	..	..
acteriosira fragilis	40	..	..	..
hizosolenia alata	80	360	1,800	2,080
— delicatula	..	..	180	..
— semispina	..	80	80	100
— styliformis	160	..	..	..
haetoceros affinis	40	80	..	80
— atlanticus	..	200	300	320
— borealis	..	140	580	300
— concavicornis	80	280	1,220	320
— debilis	..	100	..	..
— densus	60	..	520	..
— furcellatus	1,030	3,200[1])	120	80
orethron criophilum	10	..	20	20
itzschia closterium	20	..	..	..
— delicatissima	900	7,600	31,200	32,800
— seriata	50	400	..	..
ragilaria nana	..	..	800	2,000
— oceanica	350	..	..	320
— sp.	40	..	..	..
halassiothrix longissima	20	60	80	220
avicula sp.	..	20	..	20
ccolithophorides.				
occolithus pelagicus	10	40	..	..
habdosphaera stylifer	..	..	..	20
occolithophorid sp.	..	20	..	40
agellates.				
haeocystis pouchetii	162,000	360,000	20,000	3,600
hoanoflagellat	..	..	..	400
istephanus speculum	..	..	40	..
ifferent naked species	1,200	..	2,400	7,600
fusorians.				
ohmanniella ovatum	40	100	..	..

[1]) partly with restingspores.

Table 63 (continued).

Depth in m	0	10	25	50
Lohmanniella spiralis	..	40	..	..
Mesodinium rubrum	..	20	..	..
Laboea conica	160	80	160	20
strobila	..	10	..	..
spec.	10	60	80	..
Acanthostomella norvegica	..	..	40	20
Parafavella dentata	10	20	..	..
Ptychocylis urnula	..	..	20	..
Salpingella acuminata	..	..	20	..
Infusorian sp.	..	20	..	..

Appendix. Table 64.

A selected representative station (St. 4399) showing the complete composition of the plankton at the coast of the Faroes during the summer (values per 100 ccm).

Depth in m	0	25	50
Temperature in ° C	8.34	8.28	8.27
Salinity, ‰	35.28	35.28	35.28
σ_t	27.45	27.46	27.46
P_2O_5, mg/m³	50	50	50
N_{NO_3}, mg/m³	50	..	80
Peridinians.			
Gymnodinium sp.	420	640	400
Exuviaella baltica	..	20	10
Peridinium ovatum	..	..	10
Ceratium furca	..	10	..
Diatoms.			
Paralia sulcata	120	..	40
Leptocylindrus danicus	640	720	810
— minimus	2,400	3,200	1,600
Thalassiosira nordenskjöldii	60	120	80
Rhizosolenia alata	20	60	120
— faeroeensis	2,200	1,620	1,860
— semispina	40	60	80
— shrubsolei	60	40	100
Chaetoceros debilis	800	420	660
— decipiens	80	150	120
— teres	..	60	..
— sp.	760	620	1,200
Nitzschia delicatissima	5,100	6,400	6,000
Thalassiothrix nitzschioides	160	220	120
Coccolithophorides.			
Pontosphaera huxleyi	800	1,600	1,200
Flagellates.			
different naked species	9,600	7,200	8,000
Infusorians.			
Lohmanniella oviformis	40	20	..
Laboea sp.	20	..	40
Parafavella dentata	20	40	..

Appendix. Table 65.

A selected representative station (St. 4411) showing the complete composition of the plankton at the South coast of Iceland during early summer (values per 100 ccm).

Depth in m	0	10	25
Temperature in ° C	10.58	10.56	9.91
Salinity, ‰	33.61	34.67	34.88
σ_t	25.90	26.61	26.89
P_2O_5, mg/m³	5	0	0
N_{NO_3}, mg/m³	0	0	15
O_2, perc. of sat.	105.4	107.7	100.3
Peridinians.			
Gymnodinium lohmanni	20	760	120
— sp.	600	2,800	3,600
Phalacroma rotundatum	20	..	..
Dinophysis sp.	40	..	..
Goniaulax digitalis	40	..	..
Peridinium brevipes	20	..	..
— depressum	20	..	..
— ovatum	220	20	20
— pallidum	20	..	..
— pellucidum	100	20	20
— roseum	220	..	..
— subinerme	..	220	..
— triquetrum	1,080	2,700	140
— sp.	180	30	20
Ceratium longipes	40	..	..
Diatoms.			
Sceletonema costatum	..	..	80
Coscinodiscus sp.	..	20	20
Coscinosira polychorda	40	..	..
Thalassiosira sp.	20	40	60
Leptocylindrus danicus	..	120	..
— minimus	61,000	192,000	2,800
Rhizosolenia alata	..	40	..
— delicatula	..	..	140
— semispina	60	40	40
Chaetoceros cinctus	..	1,000	560
— convolutus	..	100	..
— decipiens	380	..	..
— gracilis	1,200	800	..
— laciniosus	360	240	..
— pseudocrinitus	140	..	..
— scolopendra	2,000	1,000	220
— sp.	..	60	..
Cerataulina bergonii	..	20	..
Asterionella japonica	100	..	100
Nitzschia closterium	100	500	20
delicatissima	65,000	47,200	36,800
— seriata	280	40	160
Thalassiothrix nitzschioides	200	60	280
Navicula sp.	..	..	20

Table 65 (continued).

Depth in m	0	10	25
Coccolithophorides.			
Pontosphaera huxleyi	39,600	27,200	42,400
Syracosphaera sp.	1,600	1,200	..
Coccolithus pelagicus	..	20	20
Flagellates.			
different naked species	24,600	10,800	11,600
Infusorians.			
Lohmanniella oviformis	140	60	140
Mesodinium rubrum	..	60	..
Laboea crassula	..	380	20
— conica	40	120	20
— strobila	..	60	20
— vestita	..	60	..
— spec.	60	..	..
Acanthostomella norvegica	60	20	40
Parafavella dentata	60	40	..
Tintinnopsis karajakensis	60	40	80
Ptychocylis urnula	20	..	10
Helicostomella subulata	60	..	..
Infusorian sp.	20	140	..

Appendix. Table 66.

A selected representative station (St. 4696) showing the complete composition of the plankton at the South coast of Iceland during late summer (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	9.38	9.34	9.28	8.97
Salinity, ‰	34.80	34.88	34.88	35.01
σ_t	26.92	26.98	26.99	27.10
P_2O_5, mg/m³	30	30	10	10
N_{NO_3}, mg/m³	100	125	125	125
Peridinians.				
Amphidinium sphenoides	..	40	20	..
— sp.	10	..	20	20
Gymnodinium lohmanni	20	40	30	..
— sp.	1,700	4,440	3,300	860
Exuviaella baltica	7,200	4,800	8,400	400
Dinophysis acuta	10	..	..	..
Goniaulax spinifera	10	..	..	..
Minuscula bipes	30	20	60	20
Peridinium brevipes	10	20	10	..
— pellucidum	10	..	..	..
— triquetrum	10	..	40	..
Ceratium lineatum	..	60	30	20
— longipes	..	..	10	..
Peridinian sp.	400	400	..	..

Table 66 (continued).

pth in m	0	10	25	50
atoms.				
celetonema costatum	4,900	3,900	5,200	4,340
eptocylindrus danicus	110	60	60	..
— minimus	3,200	800	1,600	..
halassiosira gravida	110	80	200	140
— nordenskjöldii	17,600	12,000	12,800	6,000
— sp.	8,400	10,400	12,000	2,800
oscinosira polychorda	100	220	..	..
hizosolenia fragillima	20	..	140	..
haetoceros cinctus	60[1])	560[1])	40[1])	420[1])
— concavicornis	..	..	20	..
— compressus	..	..	120[1])	..
— debilis	..	200	350[1])	340
— laciniosus	20	..	70	..
— perpusillus	7,200	2,400	2,000	6,000
— scolopendra	600	300	1,120	600
— similis	140	200	100	..
ucampia groenlandica	..	80	..	..
sterionella japonica	..	300	1,580	240
orethron criophilum	..	..	10	..
erataulina bergonii	..	40	..	..
Nitzschia closterium	800	1,200	160	40
— delicatissima	8,000	9,600	8,000	6,000
— seriata	..	..	220	..
halassiothrix nitzschioides	430	380	460	400
Navicula sp.	..	20	40	20
occolithophorides.				
Pontosphaera huxleyi	6,400	4,000	5,200	5,200
Syracosphaera sp.	400	400	400	..
Coccolithus pelagicus	90	60	40	..
Rhabdosphaera stylifer	..	20	..	..
Acanthoica quattrospina	..	..	20	40
lagellates.				
Eutreptia lanowii	10	..	..	..
Carteria sp.	10,000	14,800	19,200	8,400
different naked species	21,800	14,400	14,400	5,600
nfusorians.				
Lohmanniella oviformis	30	..	20	..
Laboea conica	10	..	10	..
— sp.	20	20	40	..
Parafavella dentata	..	20	..	..
Tintinnopsis karajakensis	10	..	..	..
Tintinnus lusus undae	10	..	..	..
Infusorian sp.	10	..	20	..

[1]) partly with restingspores.

Appendix. Table 67.

A selected representative station (St. 4415) showing the complete composition of the plankton at the West coast of Iceland during the maximum in May-June (values per 100 ccm).

Depth in m	0	10	25
Temperature in ° C	9.38	9.90	9.18
Salinity, ‰	34.56	34.54	34.74
σ_t	26.72	26.63	26.90
P_2O_5, mg/m³	5	5	10
N_{NO_3}, mg/m³	5	10	25
O_2, perc. of sat.	101.9	103.8	103.6
Peridinians.			
Amphidinium sphenoides	..	200	40
Gymnodinium lohmanni	40	20	100
— sp.	780	3,000	3,400
Cladopyxis setifera	..	20	..
Exuviaella baltica	..	2,400	400
Phalacroma rotundatum	..	20	..
Dinophysis acuminata	20	..	20
Goniaulax spinifera	80	20	..
Minuscula bipes	..	..	20
Diplopsalis rotunda	..	20	..
Peridinium brevipes	20	..	..
— divergens	..	20	20
— granii	..	..	40
— leonis	..	20	..
— ovatum	140	80	10
— pellucidum	60	40	80
— steinii	..	..	20
— subinerme	700	500	340
— triquetrum	540	580	680
— trochoideum	120	40	60
— sp.	100	200	120
Ceratium longipes	40	40	20
Diatoms.			
Sceletonema costatum	220	240	560
Leptocylindrus danicus	100	..	120
— minimus	22,000	26,000	13,400
Coscinosira polychorda	80	80	80
Thalassiosira gravida	100	60	460
— nordenskjöldii	100	160	480
Rhizosolenia delicatula	480	280	10,800
— faeroeensis	440	..	180
— semispina	..	..	20
Chaetoceros cinctus	2,700	5,220[1])	13,880[1])
— compressus	80	800	820
— constrictus	..	..	140
— debilis	..	580	800
— decipiens	..	80	..
— laciniosus	80	60	..
— scolopendra	..	..	200

[1]) partly with restingspores.

Table 67 (continued).

Depth in m	0	10	25
Chaetoceros similis	..	100	800
— socialis	1,000	1,800	1,800
Asterionella japonica	2,400	3,320	24,700
Nitzschia closterium	..	20	20
— delicatissima	16,400	32,000	48,000
— seriata	..	40	120
Thalassiothrix nitzschioides	620	260	160
Navicula sp.	20	60	40
Coccolithophorides.			
Pontosphaera huxleyi	1,200	5,600	8,800
Flagellates.			
Distephanus speculum	20	100	40
Cannopilus binoculus	20	..	..
different naked species	452,000	168,000	95,000
Infusorians.			
Lohmanniella oviformis	80	160	100
— spiralis	20	40	..
Mesodinium rubrum	60	60	20
Laboea conica	160	280	..
— emergens	60	40	80
— strobila	..	20	..
Parafavella dentata	40	40	..
Tintinnopsis karajakensis	..	80	20
Acanthostomella norvegica	20	10	40
Helicostomella subulata	20	140	320
Salpingella acuminata	..	20	20
Infusorian sp.	80	40	..

Appendix. Table 68.

A selected representative station (St. 4451) showing the complete composition of the plankton at the West coast of Iceland during the high of summer (values per 100 ccm).

Depth in m	0	10	25
Temperature in ° C	11.42	11.04	8.90
Salinity, ‰	34.60	34.63	34.91
σ_t	26.40	26.50	27.08
P_2O_5, mg/m³	0	10	40
N_{NO_3}, mg/m³	0	0	65
O_2, perc. of sat.	107.5	106.3	99.7
Peridinians.			
Amphidinium sp.	20	..	..
Gymnodinium lohmanni	..	90	..
— sp.	290	470	80
Exuviaella baltica	20	40	..
Dinophysis acuta	120	60	..
Diplopsalis minor	420	540	..

Table 68 (continued).

Depth in m	0	10	25
Peridinium brevipes	400	140	..
depressum	..	10	..
— divergens	..	..	10
— ovatum	..	30	..
— pellucidum	..	..	10
— triquetrum	2,000	5,600	20
— sp.	..	20	10
Ceratium fusus	..	40	..
— lineatum	..	20	..
— longipes	30	..	..
— tripos	10	..	..
Diatoms.			
Leptocylindrus minimus	120	90	..
Thalassiosira bioculata	..	10	..
— nordenskjöldii	80	60	..
Coscinosira polychorda	60	30	260
Rhizosolenia alata	..	..	10
— semispina	..	10	..
Chaetoceros cinctus	..	..	30[1]
— decipiens	..	..	60
— laciniosus	..	30	..
— sp.	10	..	20
Cerataulina bergonii	40	30	..
Nitzschia closterium	..	..	30
— delicatissima	30	..	190
Thalassiothrix nitzschioides	..	..	20
Navicula sp.	..	..	10
Coccolithophorides.			
Pontosphaera huxleyi	3,600	8,600	400
Syracosphaera sp.	10	..	..
Coccolithophorid sp.	800	2,400	8,000
Flagellates.			
different naked species	96,400	129,600	10,800
Infusorians.			
Lohmanniella spiralis	20	20	..
Mesodinium rubrum	150	90	20
Laboea sp.	..	40	..
Parafavella dentata	40	40	10
Tintinnopsis karajakensis	10	..	60
Ptychocylis urnula	..	..	30
Helicostomella subulata	40	240	20
Infusorian sp.	..	80	10

[1]) partly with restingspores.

Appendix. Table 69.

selected representative station (St. 4461) showing the mplete composition of the plankton at the Northwest ast of Iceland during a maximum in July 1932 (values per 100 ccm).

epth in m	0	10	25	50
mperature in ° C	7.84	7.61	6.38	6.11
linity, ‰	34.71	34.69	34.69	34.88
	27.09	27.10	27.27	27.42
$_2O_5$, mg/m³	5	0	20	45
NO_3, mg/m³	0	0	40	70
$_2$, perc. of sat	115.0	111.3	100.0	92.7
eridinians.				
Gymnodinium lohmanni	100	60	..	..
— sp.	200	160	900	1,200
Exuviaella baltica	300	80	..	..
Cladopyxis setifera	100	80	..	..
Goniodoma ostenfeldii	..	40	..	..
Minuscula bipes	100	40	..	..
Peridinium curvipes	..	80	..	..
— granii	..	20	..	..
— ovatum	100	60	..	..
— pellucidum	200	100	..	..
— roseum	..	20	..	..
— subinermis	..	20	..	..
— triquetrum	2,500	2,100	200	..
sp.	300	120	..	..
iatoms.				
Sceletonema costatum	4,000	780	900	120
Leptocylindrus danicus	800	320	800	20
— minimus	5,700	880	1,000	170
Thalassiosira gravida	700	160	100	10
— nordenskjöldii	..	240	200	..
— sp.	1,700	500	1,200	150
Rhizosolenia alata	100	20	..	..
— delicatula	1,000	..	..	..
— faeroeensis	100	20	..	..
— semispina	..	20	..	10
Chaetoceros compressus	4,500	5,400	1,000	160
— concavicornis	..	100	..	..
— debilis	19,000	12,800	20,000	40
— decipiens	..	120	..	..
— densus	500	..	..	..
— furcellatus	8,600	2,280	5,700[1]	190
— gracilis	100	..	..	..
— laciniosus	21,500	10,080	4,500[1]	90
— scolopendra	600	180	1,000	70
— socialis	..	1,000	..	..
teres	..	..	400	..
— sp.	2,200	720	500	70
Eucampia groenlandica	..	160	200	..
Corethron criophilum	..	20	100	40

[1]) partly with restingspores.

Table 69 (continued).

Depth in m	0	10	25	50
Nitzschia closterium	2,900	740	200	40
delicatissima	31,500	21,600	20,500	420
seriata	1,200	..	300	..
Thalassiothrix nitzschioides	700	..	..	40
Navicula sp.	..	20	100	30
Coccolithophorides.				
Coccolithus pelagicus	..	20	..	..
Rhabdosphaera hispida	200	..	..	40
Flagellates.				
Dinobryon sertularia	1,000	800	..	..
Eutreptia lanowii	100	20	..	..
different naked species	40,000	33,600	20,000	9,200
Infusorians.				
Lohmanniella oviformis	200	40	..	10
Mesodinium rubrum	..	20	..	..
Laboea conica	..	80	..	..
strobila	..	60	100	..
sp.	100	40	100	..
Parafavella dentata	..	40	..	..
Acanthostomella norvegica	..	..	100	10
Helicostomella subulata	..	20	..	..
Infusorian sp.	..	..	100	..

Appendix. Table 70.

A selected representative station (St. 4466) showing the complete composition of the plankton at the North coast of Iceland during the summer (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	7.08	6.99	4.84	4.88
Salinity, ‰	33.95	33.93	34.34	34.93
σ_t	26.60	26.60	27.30	27.65
P_2O_5, mg/m³	5	5	15	60
N_{NO_3}, mg/m³	0	0	35	275
O_2, perc. of sat	100.4	100.2	99.3	89.5
Peridinians.				
Gymnodinium lohmanni	..	..	..	50
— sp.	..	10	10	..
Diatoms.				
Thalassiosira sp.	80	..	..	20
Nitzschia delicatissima	40	50	40	20
Fragilaria nana	..	..	50	..
Flagellates.				
different naked species	19,600	68,000	447,200	6,000

Appendix. Table 71.

A selected representative station (St. 5116) showing the complete composition of the plankton at the Northeast corner of Iceland during the high of summer (values per 100 ccm).

Depth in m	0	25	50
Temperature in ° C	3.27	3.28	3.26
Salinity, ‰	34.45	34.47	34.49
σ_t	27.43	27.44	27.45
Peridinians.			
Gymnodinium sp.	220	100	40
Exuviaella baltica	20	..	.
Diatoms.			
Thalassiosira gravida	1,980	880	1,020
nordenskjoldii	9,000	10,700	7,500
— sp.	..	40	.
Coscinosira polychorda	..	80	120
Chaetoceros debilis	500	200	600
diadema	360	..	160
socialis	3,500	..	120
— sp.	1,740	1,460	1,040
Nitzschia closterium	40	60	60
— delicatissima	520	880	760
Fragilaria sp.	100	240	80
Navicula sp.	..	..	60
Flagellates.			
Phaeocystis pouchetii (colonies)	20	40	20
Choanoflagellate	..	..	20
different naked species	6,400	4,400	2,400
Infusorians.			
Parafavella dentata	20	..	..
Infusorian sp.	20	..	..

Appendix. Table 72.

A selected representative station (St. 4599) showing the complete composition of the plankton in the coastal water warmed by the summer at the East coast of Iceland (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	9.44	9.43	8.05	6.02
Salinity, ‰	34.00	34.00	34.27	34.45
σ_t	26.29	26.29	26.71	27.13
P_2O_5, mg/m³	0	0	0	0
N_{NO_3}, mg/m³	0	0	15	45
Peridinians.				
Gymnodinium lohmanni	..	..	..	10
— sp.	1,200	1,200	1,200	400
Pronoctiluca pelagica	..	10	..	..
Exuviaella baltica	100	10	120	20

Table 72 (continued).

Depth in m	0	10	25	50
Minuscula bipes	..	..	100	.
Peridinium triquetrum	40	10	40	.
Peridinium sp.	..	10	..	20
Ceratium arcticum	..	..	10	
Diatoms.				
Thalassiosira sp.	400	400	..	.
Rhizosolenia semispina	..	20	.	.
Nitzschia closterium	..	20	..	.
— delicatissima	1,600	100	1,600	100
Coccolithophorides.				
Pontosphaera huxleyi	1,600	800		.
Syracosphaera sp.	..	..	..	10
Coccolithus pelagicus	..	..	..	20
Michaelsarsia sp.	..	100	..	..
Flagellates.				
different naked species	33,600	34,800	52,800	17,200
Infusorians.				
Lohmanniella oviformis	10	30	30	.
Laboea sp.	..	20	20	10
Acanthostomella norvegica	..	10	..	..

Appendix. Table 73.

A selected, representative station (St. 4480) showing the complete composition of the plankton in the Arctic water at the East coast of Iceland during the summer (values per 100 ccm).

Depth in m	0	10	25	50
Temperature in ° C	5.41	5.30	5.21	4.97
Salinity, ‰	34.01	34.01	34.01	34.09
σ_t	26.86	26.88	26.89	26.98
Peridinians.				
Gymnodinium sp.	..	..	10	10
Peridinium triquetrum	..	10	..	..
Ceratium arcticum	..	20	..	10
Diatoms.				
Thalassiosira sp.	800	800	1,200	800
Nitzschia delicatissima	800	50	..	10
Fragilaria nana	9,600	5,200	6,400	5,600
Coccolithophorides.				
Coccolithus pelagicus	110	160	80	120
Flagellates.				
different naked species	72,400	81,200	84,000	82,400
Infusorians.				
Lohmanniella oviformis	20	..	..	..
Laboea strobila	40	120	30	..
— sp.	20	10	..	..

Appendix. Table 74.

selected representative station (St. 4483) showing the mplete composition of the plankton in the mixing area the East coast of Iceland during the summer (values per 100 ccm).

pth in m	0	10	25	50
mperature in ° C	6.78	6.01	7.24	7.20
linity, ‰	33.40	33.73	34.25	34.60	
	26.27	26.57	26.81	27.10
O_2, mg/m³	10	20	15	40
O_2, mg/m³	5	50	25	80
, perc. of sat	110.1	101.7	101.6	90.6
ridinians.				
ymnodinium lohmanni	100	50	40	20
— sp.	350	350	3,200	190
Pronoctiluca pelagica	50	280	60	..
Exuviaella baltica	400	150	800	..
Phalacroma rotundatum	..	50	..	..
Minuscula bipes	350	150	800	..
Peridinium triquetrum	950	..	..	..
Ceratium longipes	..	..	20	..
iatoms.				
Leptocylindrus danicus	100	350	..	..
— minimus	13,200	12,800	2,000	..
Coscinodiscus sp.	..	..	20	..
Thalassiosira gravida	4,400	1,000	500	60
— nordenskjöldii	12,000	2,150	3,700	..
— sp.	..	..	13,600	..
Sceletonema costatum	69,600	51,600	2,400	..
Chaetoceros concavicornis	100	100	20	..
— furcellatus	434,000	184,000	4,800	140
— similis	22,400	13,600	800	..
Eucampia groenlandica	13,200	4,800	1,200	40
Nitzschia closterium	400	..	40	..
— delicatissima	1,600	7,200	1,600	30
Fragilaria nana	3,600	1,200	3,200	1,600
occolithophorides.				
Pontosphaera huxleyi	..	1,200	14,000	8,800
Coccolithus pelagicus	..	..	40	..
Coccolithophorid sp.	..	..	20	..
lagellates.				
different naked species	42,400	21,600	48,000	8,000
nfusorians.				
Lohmanniella oviformis	550	100	20	..
Mesodinium rubrum	300	..	20	..
Laboea conica	100	..	..	..
— strobila	100	..	..	..
— sp.	150	..	..	..
Tintinnopsis karajakensis	..	..	20	..
Acanthostomella norvegica	150	..	..	..
Infusorian sp.	100	..	..	10

Appendix. Table 75.

A selected, representative station (St. 4645 in Øfjord) showing the complete composition of the plankton in an Islandic fjord without continuous contribution of nutritives from without during the summer.

Depth in m	0	10	25	50
Temperature in ° C	12,00	10,42	8,86	6,90
Salinity, ‰	31,42	33,57	34,23	34,52
σ_t	23.83	25.78	26.56	27.07
O_2, perc. of sat	104.0	110.4	107.4	99.4
Peridinians.				
Gymnodinium sp.	2,000	1,600	800	110
Exuviaella baltica	30	10	20	..
Minuscula bipes	10	..	..	..
Peridinium brevipes	..	..	..	10
— depressum	..	10	..	..
— triquetrum	550	40	30	..
— sp.	10	..	..	..
Ceratium longipes	..	40	..	..
Diatoms.				
Paralia sulcata	..	..	30	..
Sceletonema costatum	44,000	800	70	..
Leptocylindrus minimus	1,600	..	..	..
Chaetoceros concavicornis	10	..	..	..
Nitzschia closterium	10	10	..	20
— delicatissima	1,600	100	..	50
Thalassiothrix nitzschioides	60	20	..	..
Navicula sp.	30	..	20	..
Coccolithophorides.				
Pontosphaera huxleyi	400	..	..	..
Coccolithus pelagicus	..	..	10	30
Flagellates.	400	..	..	..
different naked species	20,000	43,600	18,000	2,800
Infusorians.				
Lohmanniella oviformis	30	..	10	10
Mesodinium rubrum	10	..	..	..
Laboea sp.	..	20	..	..
Tintinnopsis karajakensis	10	..	..	..
Acanthostomella norvegica	10	..	10	..
Helicostomella subulata	40	..	..	..
Infusorian sp.	20	..	..	..

Appendix. Table 76.

A selected representative station (St. 5143) showing the complete composition of the plankton in the central Arctic part of the Norwegian Sea at the beginning of the spring maximum (values per 100 ccm).

Depth in m	0	10	25	50	100
Temperature in ° C	3.61	3.58	3.24	3.23	2.88
Salinity, ‰	34.85	34.85	34.85	34.85	34.90
σ_t	27.72	27.72	27.75	27.76	27.84
Peridinians.					
Gymnodinium sp	1,200	1,200	800	400	30
Exuviaella baltica	400	400	1,200	400	..
Minuscula bipes	10	..	20	..	..
Diatoms.					
Leptocylindrus minimus	..	100	..	..	..
Coscinodiscus sp.	..	..	10	..	..
Thalassiosira gravida	90	40	..	40	20
— nordenskjöldii	30	20	..	40	..
Rhizosolenia fragillima	20	..	..	..	..
— semispina	..	..	10	..	..
Chaetoceros atlanticus	50	30	180	..	..
— borealis	60	..	30	..	..
— concavicornis	..	..	50	..	..
— debilis	..	150	..	110	..
— decipiens	290	60	40	50	..
Eucampia groenlandica	..	80	..	..	..
Corethron criophilum	..	10	..	..	..
Nitzschia closterium	10	..	..	..	10
— delicatissima	..	30	30	30	..
Fragilaria nana	20	90	110	220	120
Thalassiothrix longissima	20	10	20	..	..
— nitzschioides	40	..	..	..	..
Navicula sp.	..	20	..	..	..
Coccolithophorides.					
Pontosphaera huxleyi	1,200	400	800	800	..
Coccolithus pelagicus	1,200	1,200	1,200	400	800
Michaelsarsia sp.	400	..	..	..	..
Coccolithophorid sp.	800	800	800	800	30
Flagellates.					
Dictyocysta speculum	..	10	..	..	..
different naked species	12,000	16,400	15,000	8,400	6,000
Infusorians.					
Lohmanniella oviformis	20	20	10	..	..
Laboea strobila	80	..	..	..	..
— sp.	490	140	..	10	..
Acanthostomella norvegica	..	..	20	50	..
Infusorian sp.	40	20	20	..	..

Summary in Danish.

Materialet til det foreliggende arbejde er indsamlet paa »Dana«s togter til Færøerne, Island og Ostgrønland i aarene 1932—1934. Endvidere blev en række overfladeprøver indsamlet af magister S. Lund paa en rejse fra Island til nordøstkysten af Grønland i juni 1933.

Vandprøver fra 0, 10, 25 og 50 m blev konserveret med neutral formol. Senere er phytoplanktonet blevet talt ved hjælp af Utermöhls omvendte mikroskop. Indsamlingen af vandprøverne blev foretaget i nøje forbindelse med de hydrografiske undersøgelser, hvorved der blev bestemt temperatur, saltholdighed, iltmætning og indhold af næringssaltene fosfat og nitrat. Paa togtet i 1934 blev der endvidere foretaget bestemmelser af vandets gennemsigtighed ved hjælp af et Pulfrichfotometer.

Da undersøgelserne strækker sig fra slutningen af april til slutningen af august, er det muligt for de fleste af områderne at give en sammenfattende skildring af phytoplanktonproduktionen gennem hele produktionssæsonen. Paa grundlag heraf er søgt udredet, hvilke faktorer der har betydning for produktionen.

Begrænsende faktorer for phytoplanktonproduktionen. Stort set er der kun to faktorer, der direkte virker begrænsende paa produktionen i de nordlige farvande: lyset og mængden af næringssaltene; men disse to faktorer er igen afhængige af en hel række andre, der tildels griber ind i hinanden. En del andre faktorer, som f. eks. temperatur og saltholdighed, virker derimod i reglen kun regulerende paa planktonproduktionen, idet de blandt andet har indflydelse paa den floristiske sammensætning af planktonet, og for temperaturens vedkommende ihvertfald ogsaa paa hastigheden af stofskifteprocesserne. Antallet af overvintrende celler spiller kun en underordnet rolle med hensyn til tidspunktet for foraarsmaksimets indtræden.

Om vinteren er lyset i de foreliggende områder saa højt mod nord ikke tilstrækkelig kraftigt selv i de øverste vandlag til at bevirke en effektiv CO_2-assimilation. Medens man paa samme breddegrader ved Norges kyst allerede i begyndelsen af april finder en kratig produktion af phytoplankton, sætter derimod foraarsmaksimet ved Færøernes og Islands kyster og ude over det aabne ocean først ind i løbet af maj. Forklaringen herpaa er, at medens overfladelagene ved Norges kyst altid er mere eller mindre stabiliserede paa grund af forskelligheder i saltholdigheden, der er en følge af den baltiske overfladestrøm, indtræder stabiliseringen af overfladelagene paa det aabne hav og ved kysten af Island først naar de øverste vandlag er blevet lettere paa grund af sommeropvarmningen. Dette finder først sted i løbet af maj. Phytoplanktonorganismerne, der er uden effektiv egenbevægelse, maa følge vandringen af de vandmasser, hvori de lever. Naar vandlagene ikke er stabiliserede sker der, antagelig især ved stormfuldt vejr udstrakte vertikalbevægelser, hvorved algerne fjernes fra overfladen og lyset.

Vandets gennemsigtigned er af overordentlig stor betydning for phytoplanktonproduktionen, idet udstrækningen af de producerende overfladelag er afhængig af, hvor langt lyset kan trænge ned og levere energi til algernes kulsyreassimilation. Om foraaret ved Island er kystvandet gennemgaaende overordentlig uigennemsigtigt, hvilket skyldes opslemning af uorganisk materiale, frem for alt fint sand af vulkansk oprindelse. Saalænge vandlagene ikke endnu er stabiliserede, bliver materiale fra bunden til stadighed hvirvlet op igen; men saasnart stabilisationen er indtraadt, vil det opslemmede materiale, der ved roligt vejr synker ned fra overfladelagene, ved uroligt vejr ikke igen kunne naa herop. Vandets gennemsigtighed er derved steget ganske betydeligt. Store mængder phytoplankton nedsætter ogsaa vandets gennemsigtighed, men gennemgaaende ikke tilnærmelsesvis saa meget som det opslemmede bundmateriale om foraaret.

I strømraserne ud for fremspringende pynter ved Island som f. eks. ud for Staalbjerghuk bliver vandlagene gennemgaaende aldrig stabiliserede, og vandet vil gennemgaaende altid være uklart her. Skønt indholdet af næringssaltene altid er stort, finder der dog næsten ingen produktion sted selv midt om sommeren.

Ude paa det aabne ocean er vandet om foraaret klart, da der her kun findes smaa mængder af opslemmet materiale. Det samme er tilfældet ved kysterne af Færoerne, hvor der gennemgaaende ikke findes bundaflejringer af materiale, der kan hvirvles op. Endvidere findes der ikke som ved Island vulkansk virksomhed, hvorved der føres fint vulkansk aske ud over havet. Skønt vandlagene ved Færoerne aldrig bliver effektivt stabiliserede, sætter dog produktionen ind her i løbet af maj. Dette skyldes den store udstrækning af det euphotiske lag paa grund af havvandets gode gennemsigtighed i forbindelse med forøgelsen i daglængden, hvorved planktonalgernes reelle daglængde naar op over minimumsværdien for produktion, skønt algerne er paa en stadig vandring mellem de euphotiske overfladelag og de oligophotiske dybere vandlag.

En ringe vanddybde kan delvis ophæve virkningen af manglende stabilitet af vandlagene, idet de euphotiske vandlags relative dybde i forhold til hele vandmassen tiltager med aftagende dybde; derved stiger ogsaa planktonalgernes reelle daglængde.

Paa grund af vinterafkølingen af overfladelagene og den deraf følgende opblanding med de dybere vandmasser finder man om vinteren og i det tidlige foraar forholdsvis store mængder af næringssaltene fosfat og nitrat i alle vandlag. Under det kraftige foraarsmaksimum, som i de fleste af omraaderne sætter ind i løbet af maj bliver de tilstedeværende mængder af næringssaltene forbrugt. Hvor der ikke tilføres friske mængder af næringssaltene i løbet af sommeren hører derfor produktionen af phytoplankton næsten helt op, naar foraarsmaksimet er forbi. Dette er f. eks. tilfældet i det nordlige Atlanterhav. Hvor der derimod finder en nogenlunde regelmæssig tilblanding til overfladen af dybdevand sted, fortsætter phytoplanktonproduktionen gennem hele sommeren. Dette er tilfældet over de undersøiske rygge mellem Grønland og Island og mellem Island og Færoerne samt i Færø-Shetlandkanalen og langs Østgrønlands kyst syd for Danmarksstrædet uden for polarstrømmen, idet det atlantiske dybdevand bliver presset op langs skrænterne af bankerne. Ogsaa forskellige kystomraader faar om sommeren til stadighed tilført frisk dybdevand, f. eks. ved Færøerne og ved sydkysten af Island.

Tilførsel af næringssaltene fra land faar kun betydning i fjorde. Om sommeren kan man her lige i overfladen finde en ret beskeden produktion af phytoplankton, der er afhængig af de smaa mængder af næringssaltene, der føres ud med ferskvandet fra land.

1. **Den aarlige phytoplanktonproduktion i de forskellige omraader.** 1. Det nordlige Atlanterhav syd for Island. Naar overfladevandet er blevet stabiliseret i løbet af maj, begynder foraarsmaksimet, der varer til henimod 1. juli. Planktonet under dette er meget

rigt med coccolithophorider som den dominerende gruppe; især er *Pontosphaera huxleyi* talrig. Senere paa sommeren er phytoplanktonproduktionen yderst svag, idet der ikke tilføres overfladevandet friske mængder af næringssaltene.

2. Færø-Shetlandkanalen. Produktionen begynder omtrent paa samme tid som ude paa det aabne ocean. Planktonets sammensætning er ogsaa ganske tilsvarende. Produktionen fortsættes hele sommeren igennem, da der langs siderne af kanalen omkring 500 m isobatherne ret konstant tilføres næringsrigt dybdevand til overfladen. Planktonets sammensætning holder sig ret konstant, blot bliver senere paa sommeren diatomeerne *Fragilaria nana* og *Nitschia delicatissima* mere fremtrædende.

3. Golfstrømomraadet over den undersøiske ryg mellem Island og Færøerne. Hvad produktionen af phytoplankton angaar, svarer dette omraade ganske til det foregaaende. Ogsaa her tilføres der ret konstant næringsrigt dybdevand til overfladen.

4. Irmingerhavet. Produktionen af phytoplankton begynder antagelig gennemgaaende noget senere end i Atlanterhavet syd for Island. I begyndelsen af juni er produktionen dog i reglen igang. Da det atlantiske dybdevand presses op langs sydskraaningen af den undersøiske ryg mellem Grønland og Island og paa samme maade langs skrænten af landsoklen ved Grønlands østkyst, findes her en stadig tilførsel til overfladen af næringssaltene. Da overfladestrømmen i Irmingerhavet tildels gaar i kreds (modsat viseren paa et ur), vil næringssaltene til en vis grad blive ført ud over store dele af Irmingerhavet. Paa grund af strømmens retning er tilførslen af næringssaltene størst i den sydvestlige del af omraadet. Medens mængden af phytoplankton i omraadet mod sydvest er nogenlunde konstant gennem hele sommeren, er der derimod i sensommeren en ret betydelig nedgang i mængden i omraadet mod nordøst. Kvalitativt set svarer planktonet tildels til planktonet i Atlanterhavet syd for Island. Undertiden er coccolithophoriderne dog uden større betydning; til gengæld findes derimod diatomeerne *Fragilaria nana* og *Nitzschia delicatissima* i store mængder.

5. Den østgrønlandske polarstrøm. Saasnart isen begynder at smelte og spredes, kan lyset trænge ned i vandet, og da samtidig overfladelagene paa grund af tilblandingen af smeltevandet er blevet effektivt stabiliserede, begynder en kraftig produktion af phytoplankton i det forholdsvis næringsrige vand. I de her omtalte omraader af Østgrønlandstrømmen vil dette i reglen finde sted i løbet af juni. Under dette forsommermaksimum, der varer ca. 1 maaned, forbruges næringssaltene fuldstændigt, og da der nu paa grund af den meget kraftige stabilisering af overfladelagene slet ikke kan føres næringsrigt dybdevand til overfladen, finder man i sensommeren et overordentlig fattigt phytoplankton i Østgrønlandstrømmen. Under forsommermaksimet er det diatomeer der dominerer i planktonet, især *Chaetoceros furcellatus* og *Fragilaria oceanica*; endvidere maa nævnes flagellaten *Phaeocystis pouchetii*.

6. Blandingsomraadet mellem Østgrønlandstrømmen og Irmingerstrømmen. Dette omraade falder nogenlunde sammen med de omraader i Danmarkstrædet og langs Østgrønlands kyst, hvor næringsrigt atlantisk dybdevand bliver presset op og tilblandet overfladevandet. Der vil derfor i reglen altid være store mængder af næringssaltene tilstede i overfladen her. Gennem hele sommeren finder man derfor en ret kraftig phytoplanktonproduktion, selv om indvirkningen af de urolige hydrografiske forhold spores. Planktonet bestaar af en blanding af arter fra den polare Østgrønlandstrøm og den atlantiske Irmingerstrøm.

7. Kystomraadet ved Færøerne og Færøbanken. Produktionen af phytoplankton begynder i løbet af maj, naar dagene er blevet saa lange, at virkningen af den ved Færøerne altid manglende stabilitet af vandlagene tildels er ophævet. Gennem hele sommeren finder der en stadig produktion af phytoplankton sted; den aarlige produktion bliver derfor ret betydelig,

selv om man aldrig finder virkelig store mængder phytoplankton ved Færoerne. Der er altid konstant store mængder af næringssaltene tilstede i kystvandet ved Færoerne; dette skyldes en stadig tilblanding af atlantisk dybdevand.

I fjordene svarer phytoplanktonproduktionen nogenlunde til produktionen i kystvandet. I en tærskelfjord som Skaalefjord, hvor vandudvekslingen ogsaa for de overste vandlags vedkommende ofte er ringe, kan produktionen undertiden standse paa grund af mangel paa næringssaltene. Produktionsbetingelserne paa den isolerede Færøbanke sydvest for Færoerne svarer ret noje til produktionsbetingelserne ved kysten af Færoerne; blot har planktonet et mere oceanisk præg. Diatomeer dominerer altid i det færoske plankton, f. eks. *Rhizosolenia faröense*, *Nitzschia delicatissima* og *Chaetoceros*-arter.

8. Sydkysten af Island. Som overalt ved Islands kyster begynder produktionen først i lobet af maj, naar vandlagene er blevet stabiliserede og befriede for de store mængder bundmateriale. Skont vandlagene ved sydkysten af Island gennemgaaende er effektivt stabiliserede gennem hele sommeren, finder man dog altid her et meget rigt plankton, der skyldes en ret konstant tilblanding af atlantisk dybdevand langs skrænten af landsoklen, først og fremmest i nærheden af Vestmanoerne. Diatomeer dominerer næsten altid; især maa nævnes *Chaetoceros cinctus*, *Asterionella japonica* og *Leptocylindrus minima*. Coccolithophoriden *Pontospaera huxleyi* og forskellige peridineer kan ogsaa undertiden findes i stor mængde. Den aarlige phytoplanktonproduktion er overordentlig stor.

9. Vestkysten af Island. Det atlantiske næringsrige dybdevand presses ikke her op langs bankernes skrænter; dette er aarsag til det gennemgaaende fattige plankton her, naar foraarsmaksimet er forbi. Strømmen forer dog om sommeren undertiden et rigt plankton fra sydkysten til den sydlige del af vestkysten, og ogsaa fra den udenforliggende planktonrige Irmingerstrøm sker der undertiden en tilblanding af oceanisk plankton. Under foraarsmaksimet svarer planktonet kvalitativt gennemgaaende til planktonet paa sydkysten.

Medens vandlagene ellers ved vestkysten er kraftigt stabiliserede om sommeren, findes ved Staalbjerghuk konstant en kraftig stromrase; produktionen af phytoplankton er her overordentlig ringe. Ved nordvesthjornet af Island findes der i hojsommeren undertiden et meget rigt plankton, hvilket fremforalt maa skyldes tilblanding af næringsrigt vand fra Danmarkstrædet.

10. Nordkysten af Island. Naar næringssaltene efter foraarsmaksimet er opbrugt indfinder der sig en meget fattig tid for phytoplanktonproduktionen. Den opstigning af dybdevand, der enkelte steder lige under kysten ved bestemte vindforhold finder sted er sikkert kun ganske ubetydelig og har kun lokal betydning. Ved nordosthjornet ligesom ved nordvesthjornet finder man dog gennemgaaende om sommeren et nogenlunde rigt plankton. Her skyldes det antagelig tilblanding af næringsrigt vand fra den fra nord kommende arktiske strom.

11. Østkysten af Island. Efter foraarsmaksimets afslutning er produktionsforholdene for phytoplanktonet meget forskellige i den nordlige og sydlige del af kystomraadet. Medens den arktiske Østislandske strøm mod nord er en understrøm under sommeropvarmet kystvand, fortrænger den mod syd fuldstændig kystvandet. Paa den nordligste del af østkysten er derfor planktonet meget fattigt om sommeren, medens det længere mod syd, hvor det næringsrige arktiske vand er kommet op til overfladen, er rigt. I særlig grad er dette tilfældet i blandingsomraadet med det mod syd liggende atlantiske vand. Stromraserne, f. eks. ud for Langanes og Seydisfjord, er gennemgaaende fattige med hensyn til phytoplankton. Planktonet i det arktiske vand ved østkysten har ofte et oceanisk præg; den oceaniske art *Fragilaria nana* er f. eks. undertiden tilstede i stor mængde.

12. De islandske fjorde. Produktionen begynder her en del tidligere om foraaret end i det aabne kystvand; i et beskyttet farvand er den vertikale bevægelse af vandmasserne gennemgaaende kun ringe, selv om vandlagene ikke er stabiliserede. I enkelte fjorde, som f. eks. Seydisfjord fores til stadighed næringsrigt vand ind af tidevandsstrømmen. Her foregaar der derfor gennem hele sommeren en kraftig planktonproduktion. I de øvrige fjorde vil man derimod om sommeren gennemgaaende kun finde er ret fattigt plankton, der er afhængig af en mindre tilførsel af næringssaltene fra land. Planktonet i fjordene svarer i reglen kvalitativt til planktonet i kystvandet udenfor.

13. Den centrale »arktiske« del af Norskehavet. Produktionen af phytoplankton begynder i løbet af maj; naar næringssaltene er opbrugt i overfladelagene vil en fattig periode for planktonet indtræde. Planktonet svarer kvalitativt nogenlunde til planktonet i det nordlige Atlanterhav. Coccolithophoriden *Coccolithus pelagicus* synes dog at spille den største rolle.

Produktion af phytoplankton og fiskepopulationer. Områder med stor produktion af phytoplankton falder i reglen sammen med områder med store fiskepopulationer. Sydkysten af Island, hvor langt den største produktion af phytoplankton blev paavist, er saaledes sædet for et af verdens største fiskerier! Men områder med store fiskepopulationer behøver ikke altid at falde sammen med områder med stor produktion af phytoplankton. Saaledes er phytoplanktonproduktionen ved nordkysten af Island, hvor man om sommeren finder store sildestimer, paa denne aarstid ringe; men man maa tage i betragtning, at sildene ikke lever direkte af phytoplanktonet men derimod af copepoden *Calanus finmarchicus*, der om sommeren findes her i store mængder. Hovedmængden af disse er dog ikke vokset op ved nordkysten af Island, men er ført herhen med strømmen fra vest- og sydkysten og antagelig ogsaa fra Danmarkstrædet.

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